PUBLIC DOCUMENT . . . . . No. 33.

TENTH ANNUAL REPORT

OF THE

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1898.

BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
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HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

By act of the General Court, the Hatch Experiment Station and the State Experiment Station have been consolidated under the name of the Hatch Experiment Station of the Massachusetts Agricultural College. Several new divisions have been created and the scope of others has been enlarged. To the horticultural has been added the duty of testing varieties of vegetables and seeds. The chemical has been divided, and a new division, "Foods and Feeding," has been established. The botanical, including plant physiology and disease, has been restored after temporary suspension.

The officers are: —

Henry H. Goodell, LL.D.,	*Director.*
William P. Brooks, Ph.D.,	*Agriculturist.*
George E. Stone, Ph.D.,	*Botanist.*
Charles A. Goessmann, Ph.D., LL.D.,	*Chemist* (fertilizers).
Joseph B. Lindsey, Ph.D.,	*Chemist* (foods and feeding).
Charles H. Fernald, Ph.D.,	*Entomologist.*
Samuel T. Maynard, B.Sc.,	*Horticulturist.*
J. E. Ostrander, C.E.,	*Meteorologist.*
Henry M. Thomson, B.Sc.,	*Assistant Agriculturist.*
Ralph E. Smith, B.Sc.,	*Assistant Botanist.*
Henri D. Haskins, B.Sc.,	*Assistant Chemist* (fertilizers).
Charles I. Goessmann, B.Sc.,	*Assistant Chemist* (fertilizers).
George D. Leavens, B.Sc.,	*Assistant Chemist* (fertilizers).
Edward B. Holland, B.Sc.,	*Assistant Chemist* (foods and feeding).
Fred W. Mossman, B.Sc.,	*Assistant Chemist* (foods and feeding).
Benjamin K. Jones, B.Sc.,	*Assistant in Foods and Feeding.*
Robert A. Cooley, B. Sc.,	*Assistant Entomologist.*
G. A. Drew, B. Sc.,	*Assistant Horticulturist.*
H. D. Hemenway, B.Sc.,	*Assistant Horticulturist.*
H. H. Roper, B.Sc.,	*Assistant in Foods and Feeding.*
A. C. Monahan,	*Observer.*

The co-operation and assistance of farmers, fruit growers, horticulturists and all interested, directly or indirectly, in agriculture, are earnestly requested. Communications may be addressed to the "Hatch Experiment Station, Amherst, Mass."

The following bulletins are still in stock and can be furnished on demand: —

No. 27. Tuberculosis in college herd; tuberculin in diagnosis; bovine rabies; poisoning by nitrate of soda.
No. 28. Canker, army and corn worms; red-humped apple-tree caterpillar; antiopa butterfly; currant stem girdler; imported elm-bark louse; greenhouse orthezia.
No. 29. Fungicides and insecticides; new spraying pump; spraying calendar.
No. 33. Glossary of fodder terms.
No. 35. Agricultural value of bone meal.
No. 36. Imported elm-leaf beetle; maple pseudococcus; abbot sphinx; San José scale.
No. 37. Report on fruits, insecticides and fungicides.
No. 38. Fertilizer analyses; composition of Paris green; action of muriate of potash on the lime resources of the soil.
No. 41. On the use of tuberculin (translated from Dr. Bang).
No. 42. Fertilizer analyses; fertilizer laws.
No. 43. Effects of electricity on germination of seeds.
No. 44. Variety tests of fruits; tests of vegetable seeds.
No. 45. Commercial fertilizers; fertilizer analyses; fertilizer laws.
No. 46. Habits, food and economic value of the American toad.
No. 47. Field experiments with tobacco.
No. 48. Fertilizer analyses.
No. 49. Fertilizer analyses.
Special bulletin, — The brown-tail moth.
Index, 1888–95.

Of the other bulletins, a few copies remain, which can only be supplied to complete sets for libraries.

The work during the year has been unusually diversified in its character and importance, a result of the numerous problems sent in for solution. In the agricultural division, soil tests with corn and potatoes grown in several localities have been continued; a comparison of different fertilizers

has been made; "Nitragin" has again been tried, with negative results; and an interesting test has been carried on of twenty varieties of corn, eighty-one of potatoes, sixty of grasses, twenty-one of millets and four of clover.

In the division of chemistry (fertilizers), aside from the six hundred analyses of licensed fertilizers and manurial substances, valuable work has been done for the tobacco-growers of the Connecticut valley in the analyses of tobacco leaves grown with different fertilizers, testing of the quality of ash and burning quality, and suggestions as to methods of planting, fertilizers to be employed and mechanical preparation of the soil.

In the botanical division, investigations have been carried on of the brown rot of stone fruit, the chrysanthemum rust, the leaf blights of certain native trees, as the sycamore, butternut, chestnut and black cherry, with recommendations of treatment for the brown rot and chrysanthemum rust.

The horticultural division has continued its work of testing varieties of fruit and seeds of vegetables, and has entered upon an investigation of the use of hydrocyanic acid as an insecticide.

From the entomological division have issued two important bulletins on the habits, food and economic value of the American toad and the brown-tail moth. A monograph on the plume-moths (some varieties of which attack plants of economic value and those raised for ornamental purposes) has been completed. The superiority of spraying for the canker worm over ink bands and oil troughs has been demonstrated, and investigations carried on of new insecticides with which to assail the gypsy moth.

A series of observations for the electrical determination of moisture in the soil, in connection with the growth of corn, were undertaken by the meteorological division. Owing to breaks in the circuit and other causes that made the instrument fail to work, and the abnormally wet weather of the summer, the results were not entirely satisfactory, and the observations will be repeated the coming season.

Three investigations in the division of foods and feeding are worthy of special note: (*a*) On the comparative values

of corn meal and hominy and cerealine feeds for pork production, when fed in combination with skim-milk. It was found that the pigs did quite as well on these feeds as on an equal amount of corn meal. (*b*) On salt-marsh hay. It was found to possess less feeding value than English hay, but, combined with grain and ensilage, produced nearly as much milk and butter as an equal amount of English hay thus combined. (*c*) On cotton-seed feed as a hay substitute for milch cows. More energy was used up in its digestion than in hay, and it was concluded that Massachusetts farmers would derive no benefit from feeding this material in place of hay.

Reports of the different divisions, giving in detail the work of the year, accompany this brief summary.

ANNUAL REPORT

OF GEORGE F. MILLS, *Treasurer* OF THE HATCH EXPERIMENT STATION OF MASSACHUSETTS AGRICULTURAL COLLEGE,

For the Year ending June 30, 1897.

Cash received from United States treasurer, . . .		$15,000 00
Cash paid for salaries, ...	$5,087 75	
for labor, ...	3,312 26	
for publications, ...	2,354 06	
for postage and stationery, . . .	264 11	
for freight and express, . . .	245 78	
for heat, light and water, . . .	193 31	
for seeds, plants and sundry supplies, .	600 55	
for feeding stuffs, ...	185 11	
for library, ...	1,139 85	
for tools, implements and machinery, .	272 21	
for furniture and fixtures, . . .	33 43	
for scientific apparatus, . . .	226 83	
for live stock, ...	125 45	
for travelling expenses, . . .	352 32	
for contingent expenses, . . .	42 73	
for building and repairs, . . .	564 25	
		$15,000 00
Cash on hand July 1, 1896, ...	$1,042 92	
Received from State treasurer, . . .	10,000 00	
from fertilizer fees, ...	4,087 75	
from farm products, ...	1,934 15	
from miscellaneous sources, . . .	1,022 19	
		$18,087 01
Cash paid for salaries, ...	$10,784 83	
for labor, ...	1,075 81	
for publications, ...	175 03	
for postage and stationery, . . .	156 18	
for freight and express, . . .	187 48	
for heat, light and water, . . .	361 64	
Amount carried forward, . . .	$12,740 97	

Amount brought forward, . . .	$12,740 97	
Cash paid for chemical supplies, ...	592 48	
for seeds, plants and sundry supplies, .	515 54	
for fertilizers, ...	1,074 41	
for feeding stuffs, ...	559 24	
for library, ...	61 82	
for tools, implements and machinery, .	28 62	
for furniture and fixtures, . . .	176 12	
for scientific apparatus, . . .	357 48	
for live stock, ...	359 45	
for travelling expenses, . . .	72 72	
for contingent expenses, . . .	273 03	
for building and repairs, . . .	1,255 40	
Cash on hand June 30, 1897, ...	19 73	
		$18,087 01

AMHERST, MASS., Aug. 30, 1897.

I, Charles A. Gleason, duly appointed auditor of the corporation, do hereby certify that I have examined the books and accounts of the Hatch Experiment Station of the Massachusetts Agricultural College for the fiscal year ending June 30, 1897; that I have found the books well kept and the accounts correctly classified as above; and that the receipts for the year are shown to be $33,087.01, and the corresponding disbursements $33,067.28. All the proper vouchers are on file and have been by me examined and found to be correct, there being a balance of $19.73 on accounts of the fiscal year ending June 30, 1897.

CHARLES A. GLEASON,
Auditor.

REPORT OF THE AGRICULTURIST.

WILLIAM P. BROOKS.

Soil Tests.

Four soil tests upon the plan heretofore followed were attempted during the past year; viz., with corn in Norwell and Montague, with potatoes and with onions (and later cabbages) upon our home grounds. Only the tests in Norwell and with potatoes upon our home grounds were successfully carried through.

Unfavorable weather conditions destroyed the onions and cabbages upon our south soil-test acre. The field was sown to white mustard late in July. But four plots furnished sufficient growth to cut and weigh; viz., lime plot, 1 pound; manure plot, 425 pounds; nitrate and dissolved bone-black, 45 pounds; potash and dissolved bone-black, 25 pounds; nitrate, dissolved bone-black and potash plot, 255 pounds,—all green weights.

The field has now been used nine years in soil-test work, and we have a high degree of one-sided exhaustion on most of the plots. The close dependence of the mustard upon a supply of phosphoric acid (furnished by the bone-black) is brought out, as was the case in 1895; but phosphoric acid alone can no longer produce any growth of mustard upon this soil. The addition of either nitrogen or potash helps it, the former most; but not much growth is produced unless all three are supplied.

The soil test with corn in Montague was ruined by wire and cut worms. As nearly as could be determined from the portion of the crop left, nitrogen seemed the most necessary element upon this soil.

1. Soil Test with Corn. Norwell.

This is the second year of soil-test work in this field, the crop last year also being corn. Last year potash was the controlling element; the result this year is the same. Muriate of potash, at the rate of 160 pounds per acre, gives an average increase at the rate of 36.3 bushels of grain and 2,203 pounds of stover; nitrate of soda, at the same rate per acre, gives an average increase of 8.3 bushels of grain and 325 pounds of stover; dissolved bone-black, at the rate of 320 pounds per acre, gives an average increase of 15.3 bushels of grain and 455 pounds of stover. Five cords of manure increase the crop by 26.4 bushels of grain and 3,450 pounds of stover per acre; complete fertilizer (nitrate, dissolved bone-black and potash at above rates) gives an increase of grain 52.5 bushels and stover 2,455 pounds; lime and plaster both produce apparent small increases.

2. Soil Test with Potatoes. Amherst.

The field upon which this test was carried out lies upon our own grounds. It has a medium, well-drained loam, and has been seven years in soil-test experiments. The crops in order of succession have been potatoes, corn, soya beans, oats, grass and clover (two years), and cabbages and Swedish turnips. This year the phosphoric acid gives the largest average increase in crop, viz., at the rate of 26.6 bushels of merchantable tubers per acre; nitrogen gives an increase of 11.3 bushels merchantable tubers and potash an increase of 7.2 bushels. The soil, however, is very generally exhausted, and no single fertilizer or combination of either two or all three gave a good crop. The apparent superiority of the phosphoric acid and nitrogen is chiefly due to the fact that the plot to which those two elements alone were applied was for some reason (not believed to be the effect of the fertilizer alone) nearly twice as great as that upon any other plot. Had the crop where the potash was added to the nitrogen and phosphoric acid been better or even as good as that where the phosphoric acid and nitrogen alone were used, we should be justified in the conclusion

that the nitrogen and phosphoric acid are the elements chiefly required. The crop where all three elements were combined was, however, much inferior to that where the nitrogen and phosphoric acid were used without potash. We must therefore conclude that some disturbing factor, at present unknown, influenced the results; and we are, therefore, unable to draw practical conclusions which throw light upon the proper practice to be followed in manuring the potato crop.

Manure Alone v. Manure and Potash.

An experiment in continued corn culture for the comparison of an average application of manure with a small application of manure used in connection with muriate of potash was begun in 1890. A full account of the results will be found in the annual reports of 1890–95, and in the latter year a general summary of the results is given.

The land used in this experiment was seeded with a mixture of timothy, red-top and clover in the standing corn in July of last year. A good stand of grass and clover was secured, although the latter was rather unevenly developed in different parts of the field, suggesting a possible lack of thoroughness in mixing the seeds.

No manure or potash has been used this year. The field includes four plots of one-fourth of an acre each. The results for 1897 are shown below: —

Plot 1 (1½ cords of manure alone, 1890–96): hay, 1,420 pounds; rowen, 783 pounds.

Plot 2 (1 cord manure and 40 pounds of muriate of potash, 1890–96): hay, 885 pounds; rowen, 483 pounds.

Plot 3 (manure alone, as for Plot 1): hay, 1,380 pounds; rowen, 785 pounds.

Plot 4 (manure and potash, as for Plot 2): hay, 1,037½ pounds; rowen, 590 pounds.

The averages are as follows: —

Plots 1 and 3 (manure alone, 1890–96): hay, 1,403½ pounds; rowen, 784 pounds.

Plots 2 and 4 (manure and potash, 1890–96): hay, 961¼ pounds; rowen, 536½ pounds.

Combining the figures showing the averages of hay and rowen, we find that plots 1 and 3 have produced an average of 2,187 pounds per plot, which is at the rate of 4 tons, 748 pounds, per acre. Plots 2 and 4 have produced an average of 1,497¼ pounds per plot, which is at the rate of 9 pounds less than 3 tons per acre. The larger quantity of manure, then, produced this year about 1⅓ tons more per acre than the manure and potash. This is a large difference, but a difference which was to be anticipated, in view of the much larger quantity of plant food which has been applied to these plots. It remains to be seen whether the clover on plots 2 and 4 will be capable of so enriching the soil in nitrogen as to remove or lessen this difference in succeeding years.

"Special" Corn Fertilizer v. Fertilizer richer in Potash.

This experiment was begun with a view of comparing the results obtained with a fertilizer proportioned like the average of the "*special*" *corn fertilizers* found upon our markets in 1891 with those obtained with a fertilizer richer in potash but furnishing less nitrogen and phosphoric acid.

Corn was grown during each of the years from 1891 to 1896 inclusive. From 1891 to 1895 it was found that the fertilizer richer in potash gave the more profitable results. In 1896 there was no practical difference. It was decided during the season of 1896 that it might be possible to derive a greater benefit from the larger quantity of potash applied to two of the four plots if grass and clover should be grown in rotation with the corn. Accordingly the land was seeded with a mixture of timothy, red-top and clover in the standing corn in July, 1896. The field is divided into four plots, of one-fourth of an acre each. The materials applied to the several plots are shown in the following table: —

FERTILIZERS.	Plots 1 and 3 (Pounds each).	Plots 2 and 4 (Pounds each).
Nitrate of soda,	20	18
Dried blood,	30	30
Dry ground fish,	30	20
Plain superphosphate,	226	120
Muriate of potash,	22.5	60
Cost of materials per plot,	$3 23	$3 10

Fertilizers were applied evenly broadcast on April 11. The yields the past year are shown below: —

Plot 1, "special" fertilizer: hay, 795 pounds; rowen, 130 pounds.

Plot 2, fertilizer richer in potash: hay, 810 pounds; rowen, 129 pounds.

Plot 3, "special" fertilizer: hay, 725 pounds; rowen, 97 pounds.

Plot 4, fertilizer richer in potash: hay, 617 pounds; rowen, 165 pounds.

The average yield on plots 1 and 3 is: hay, 760 pounds; rowen, 113½ pounds. On plots 2 and 4: hay, 713½; rowen, 147 pounds. Putting the crops of hay and rowen together, we have an average from 1 and 3 of 873½ pounds, and from 2 and 4 of 860½ pounds. The difference, 13 pounds, is too small to be regarded as of much significance. The greater rowen crop produced by plots 2 and 4 is perhaps to be attributed to the larger amount of potash which has been applied to these plots, which favors especially the growth of the clovers. Inequality of moisture conditions, however, has been the apparent cause of a very uneven development of clover on different parts of the field, and the influence of the potash does not show as clearly as was anticipated.

Natural Phosphates compared with Each Other and with Acid Phosphate. (Field F.)

This series of experiments was begun by Dr. Goessmann in 1890, with a view of determining whether it is not more profitable to employ one of the cheaper natural phosphates than to use the more costly acid phosphate. A full account of the experiment and the results obtained up to the end of 1896 is given by Dr. Goessmann in our ninth annual report. It is only necessary to restate the following points: —

The field was at first divided into five plots, containing about 6,600 square feet each. These plots received equal money's worth (on the basis of prices in 1890) of the phosphates used, as follows: Plot 1, phosphatic slag; Plot 2, Mona guano; Plot 3, at first, apatite; later, Florida phosphate; Plot 4, South Carolina phosphate; Plot 5, dissolved bone-black. Plot 3, as above stated, received an application of ground apatite in 1890. In 1891 it was found impossible to obtain this material, and no phosphate of any kind was applied to this plot. In 1892 and 1893 ground hard Florida phosphate was applied to this plot. It is not believed, however, that it is fair to this phosphate to compare it with the others, since it has been used only two years, while the others have been applied for four years.

From the beginning, each of these five plots has received the same application of nitrate of soda and potash-magnesia sulphate. The quantities of these applied per plot during the first four years were about 44 pounds of the former and 66 pounds of the latter.*

Since 1894 no phosphate of any kind has been applied to these plots, but the quantity of nitrate of soda and of potash-magnesia sulphate has been used in one-half greater quantities.

At first Dr. Goessmann included no plot on which phosphate was not used for comparison with others. Later such a plot was added, but it was left entirely unmanured until 1896. During 1896 and 1897 it has received the nitrate of

* The plots in this experiment differ from each other by a few square feet in size, and the fertilizers have from the beginning varied in proportion as the size varied.

soda and potash-magnesia sulphate at the same rate as the other plots.

The yield of the plots receiving phosphate for each of the years 1890–96 inclusive will be found in our ninth annual report. This report also contains a statement showing the amounts of phosphoric acid applied and removed from each plot during each of these years. This statement shows an excess added over and above that removed from each of the plots at the end of the season of 1896 as follows: where phosphatic slag had been used, the amount of phosphoric acid remaining was 65.6 pounds; where Mona guano had been used, 44.2 pounds; where apatite and Florida phosphate had been used, 141.7 pounds; where South Carolina rock phosphate had been used, 115.0 pounds; and where acid phosphate had been used, 21.8 pounds.

The crop during the past year was Swedish turnips. The field had been sown with rye for winter protection in the fall of 1896. The growth of the rye was characterized as poor. It was ploughed on June 1, the land was harrowed on the 2d, and on the 3d of June, Laing's Swedes were sown in drills two feet apart. The seed germinated promptly and evenly, but the season was much too wet for the best growth of the crop. It was, however, kept free from weeds by frequent cultivation. The crop was thinned on June 20 to eight inches. It was harvested November 2–4. The turnips were poor in quality, small, and a few of them decayed.

The yields of the several plots were as follows: —

	Roots (Pounds).	Tops (Pounds).
Plot 0, no phosphate, ...	830	185
Plot 1, phosphatic slag, ...	1,870	480
Plot 2, Mona guano, ...	3,655	800
Plot 3, Florida hard phosphate, . . .	820	400
Plot 4, South Carolina rock phosphate, .	1,965	560
Plot 5, dissolved bone-black, . . .	1,619	370

It will be noticed that the crop on the phosphatic slag, Mona guano and South Carolina rock surpasses that where dissolved bone-black was used, and that the Mona guano gives nearly twice the product obtained by either the slag or the South Carolina rock. It will be further noticed that the Florida phosphate yields practically the same amount of roots as the plot receiving no phosphate. None of the crops secured this year can be regarded as good. The largest yield, that on the Mona guano plot, is at the rate of rather less than 12 tons per acre. A good crop should be about 20 tons per acre. The results of this year, therefore, although showing marked differences, are not regarded as decisive. The peculiarities of the season produced an unhealthy condition, which interfered with the full action of the fertilizers employed.

Comparison of Different Phosphates.

The results of the experiments inaugurated by Dr. Goessmann for the comparison of different phosphates with acid phosphate having proved so interesting and valuable, it was decided to inaugurate another series of experiments, including a greater number of materials supplying phosphoric acid. It was further thought best to apply these materials upon the basis of equal quantities of phosphoric acid to each plot, rather than on the basis of equal money's worth, as in the experiments planned by Dr. Goessmann.

The land selected for the experiment was fairly level, with a medium heavy loam. It had been in grass for many years. In April, 1896, it received an application of 600 pounds of ground bone and 200 pounds of muriate of potash per acre. The season was very dry, and the grass derived little benefit from the fertilizers. The grass was cut about the middle of June, and the field was ploughed on June 24 and 25, 1896, and planted to Longfellow corn. The corn was cut when in the milk, September 26, and weighed as put into the silo. The field had been divided into 13 plots, of one-eighth of an acre each, separated by suitable unmanured strips. The yields of corn in 1896 were as follows: —

Plot 1, 2,640 pounds; Plot 2, 2,990 pounds; Plot 3, 2,915 pounds; Plot 4, 3,555 pounds; Plot 5, 2,885 pounds; Plot 6, 2,905 pounds; Plot 7, 2,850 pounds; Plot 8, 3,020 pounds; Plot 9, 3,160 pounds; Plot 10, 3,095 pounds; Plot 11, 3,000 pounds; Plot 12, 3,090 pounds; Plot 13, 3,440 pounds.

These weights were taken with a view to determining whether these plots were fairly even in fertility. It will be noticed that with three exceptions, plots 1, 4 and 13, this appears to be the case. Plot 1 is apparently poorer than the average, while plots 4 and 13 are better.

In 1897 the soil was thoroughly prepared by the use of the wheel harrow. Fertilizers were applied May 11. Each plot in the field received the following materials: potash-magnesia sulphate, 50 pounds; nitrate of soda, 30¼ pounds; sulphate of potash, high grade, 12½ pounds. These materials supplied the potash and nearly all the nitrogen estimated to be required. Some of the phosphates to be employed (the bone meals), however, contained nitrogen as well as phosphoric acid, and, to equalize conditions on all the plots, sufficient hoof meal was applied to those not receiving bone to make the quantity of nitrogen applied to each plot throughout the field the same.

The plots contained, as stated, one-eighth of an acre each, and the materials used furnished to each plot phosphoric acid, 12 pounds; nitrogen, 6½ pounds; potash, 19 pounds.

The fertilizers used per plot (in addition to nitrate of soda and sulphate of potash which were used alike on each as stated above) are shown below: —

Plot 1: hoof meal, 11¾ pounds. Plot 2: hoof meal, 11¾ pounds; apatite, 32 pounds. Plot 3: hoof meal, 11¾ pounds; South Carolina rock phosphate, 47 pounds. Plot 4: hoof meal, 11¾ pounds; Florida soft phosphate, 45½ pounds. Plot 5: hoof meal, 11¾ pounds; slag, 67¼ pounds. Plot 6: hoof meal, 11¾ pounds; Navassa phosphate, 49 pounds. Plot 7: hoof meal, 11¾ pounds. Plot 8: hoof meal, 11¾ pounds; dissolved bone-black, 70 pounds. Plot 9: hoof meal, $\frac{6}{16}$ pound; raw bone meal, 45 pounds. Plot 10: hoof meal, $1\frac{3}{16}$ pounds; dissolved bone meal, 73¼ pounds. Plot 11: steamed bone meal, 48¼ pounds. Plot 12: hoof meal, 11¾ pounds; acid phosphate, 90½ pounds. Plot 13; hoof meal, 11¾ pounds.

The variety of corn raised was Sibley's Pride of the North, which was planted on May 17, replanted as far as necessary on June 1, and thinned to one plant per foot in the drill early in June. The extraordinary precipitation of the season kept the soil too wet the greater part of the time during the month of July, and the crop was prevented from doing its best. It was cut and stooked September 21, and husked about the last of October.

The yield per plot and the calculated rates per acre are shown below: —

NAMES.	Corn (Pounds).	Stover (Pounds).	Corn per Acre (Bushels).	Stover per Acre (Pounds).
Plot 1, no phosphate, . . .	585	580	58.500	4,640
Plot 2, apatite, ...	565	475	56.500	3,800
Plot 3, South Carolina rock phosphate	645	535	64.500	4,280
Plot 4, Florida soft phosphate, .	725	620	72.500	4,960
Plot 5, phosphatic slag, . .	620	620	62.000	4,960
Plot 6, Navassa phosphate, . .	678¼	610	67.825	4,880
Plot 7, no phosphate, . . .	643¼	542	64.325	4,336
Plot 8, dissolved bone-black, .	618¼	548	61.825	4,384
Plot 9, raw bone meal, . . .	673¼	570	67.325	4,560
Plot 10, dissolved bone meal, .	633¼	550	63.325	4,400
Plot 11, steamed bone meal, . .	503¼	450	50.325	3,600
Plot 12, acid phosphate, . .	628¼	540	62.825	4,320
Plot 13, no phosphate, . . .	673¼	590	67.325	4,720

It will be noticed that one of the best crops in the field was produced where no phosphate was used, and that the yield on the plots to which phosphates were applied varies without apparent relation to the availability of the phosphoric acid in the materials used. Under these circumstances, extended discussion of the results is not called for.

The unfavorable influence of the season and possible differences in natural fertility of the soil serve to obscure the action of the phosphates employed.

Leguminous Crops (Clover, Pea and Bean, or "Pod" Family) as Nitrogen Gatherers. (Field A.)

A full history of the field since 1884 is given by Dr. Goessmann in our ninth annual report. The years 1884–88 were preparatory; the experiment proper began in 1889. The objects in view have been: —

1. To determine the extent to which plants of the clover family are capable of enriching the soil in nitrogen taken by them from the air through the agency of the nodular bacteria found upon their roots.

2. To compare nitrate of soda, sulphate of ammonia, dried blood and barn-yard manure as sources of nitrogen.*

The field is divided into eleven $\frac{1}{10}$ acre plots, numbered from 0 to 10. Three plots, 4, 7 and 9, have received no application of nitrogen-containing manure or fertilizer since 1884. One (0) has received barn-yard manure; two (1, 2), nitrate of soda; three (5, 6, 8), sulphate of ammonia; and two (3, 10), dried blood every year since 1889. These materials have been used in such amounts as to furnish nitrogen at the rate of 45 pounds per acre each year. All the plots have received, yearly, equal amounts of phosphoric acid and potash. The quantities applied have furnished, per acre, phosphoric acid 80 pounds, and potash 125 pounds, from 1889 to 1894 and the past season. In 1895 and 1896 double these quantities were used. Dr. Goessmann reports: † —

> The total yield of crops on the plots receiving no nitrogen, as compared with those receiving nitrogen, was in the several years as follows: —
>
> With corn in 1889, one-fifth less.
> With oats in 1890, one-fifth to one-sixth less.
> With rye in 1891, one-fifth to one-sixth less.
> With soya beans in 1892, one-third to one-fourth less.

* Only such details are given here as are necessary to a general understanding of the subject; full information is found, as stated above, in our ninth annual report.

† Ninth annual report, Hatch Experiment Station, page 175.

In 1893 the crop was oats, and the yield of grain was from one-seventh to one-eighth less on the plots receiving no nitrogen than the average of those receiving nitrogen. Here the interposition of a leguminous crop (soya bean in 1892) appears to have lessened the proportional inferiority of the plots which received no nitrogen. In 1894 the crop was again the soya bean. The plots without nitrogen give a yield about one-third less than the average of the others. Thus far it will be seen that the soya bean has not shown that degree of independence of soil nitrogen of which it is supposed to be capable. To an even greater degree than the grain crops it is benefited by nitrogen manuring. This fact may perhaps be accounted for because of conditions unfavorable to bacterial life in this soil; but as to the nature of such unfavorable conditions we are at present ignorant.

In 1895 the crop was oats, and results showed no improvement in proportional yield on the plots receiving no nitrogen which could be attributed to the preceding bean crop. This may be in part due to the fact that the bean has a rather limited root system, and leaves behind but little stubble.

In 1896 the crop was again the soya bean, which once more showed marked inferiority on the no-nitrogen plots. An attempt to seed the land to clover in the standing beans proved a failure, on account of the dry season and the too dense shade made by the crop of beans.

The crop the past season has been oats. The yield per plot of straw and grain, the rate per acre and remarks upon the quality of the grain are given below. In this table the no-nitrogen plots are italicised.

Nitrogen Experiment.

PLOT.	Weight per Plot One-tenth Acre.		Yield per Acre.		Remarks on Grain.
	Straw (Pounds).	Oats (Pounds).	Straw (Pounds).	Oats (Bushels).	Kernels.
Nitrate of soda. . .	500	159	5,000	49.68	Light.
Nitrate of soda, . .	400	147	4,000	45.93	Light.
Dried blood. . .	215	122	2,150	38.12	Good.
No nitrogen, . .	*120*	*69*	*1,200*	*21.56*	Good.
Sulphate of ammonia, .	340	137	3,400	42.81	Poorer than No. 3.
Sulphate of ammonia. .	275	97	2,750	30.31	Good.
No nitrogen, . .	*120*	*77½*	*1,200*	*24.21*	Good.
Sulphate of ammonia, .	350	127	3,500	39.68	Good.
No nitrogen, . .	*130*	*75*	*1,300*	*23.43*	Good.
Dried blood, . .	220	126	2,200	39.37	Fair.
Barn-yard manure, .	220	125	2,200	39.06	Fair.

Calculation shows that the average total weight of crop is a little less than one-half as great on the plots not manured with nitrogen as the average of the other plots. The crop of grain is a little more than one-half as great. We find, then, not the least evidence of any ability on the part of the soya bean when grown before a grain crop (and harvested) to make nitrogen manuring of the grain crop unnecessary. On the contrary, the proportional yield of the no-nitrogen plots is this year the lowest it has ever been in these experiments.

The Relative Value of the Different Manures furnishing Nitrogen.

The nitrate of soda gives the largest crop. Next in order of yield come the barn-yard manure, dried blood and sulphate of ammonia; but between these there is not much difference. On plots 2, 3, 4, 6, 7, 8 and 9 the source of potash is the muriate; on all others it is double sulphate of

potash-magnesia. The yield of oats is in every instance greater where the sulphate is used under otherwise similar manuring. The superiority is most marked when sulphate of ammonia is the source of nitrogen.

Muriate compared with Sulphate of Potash in connection with Sulphate of Ammonia for Corn.

Results obtained with different crops in the special nitrogen tests on Field A during previous years having indicated an injurious effect, due to the combination of muriate of potash and sulphate of ammonia,* it was decided to undertake experiments upon a larger scale, with the view of bringing out more clearly the significance or importance of this effect. Accordingly two plots of land of one-half acre each, lying on the east side of the highway, were set apart for this experiment. This land had previously been used in experiments to determine the relative value of phosphatic slag and ground bone as sources of phosphoric acid. These experiments were begun in 1894 and continued until 1896. The crops had been oats, corn and millet. An account of these experiments will be found in the annual reports covering the years named.

The following fertilizers were applied this year, broadcast, after ploughing, and harrowed in: —

North plot: sulphate of ammonia, 152 pounds; muriate of potash, 120 pounds; acid phosphate, 160 pounds.

South plot: sulphate of ammonia, 152 pounds; sulphate of potash, 120 pounds; acid phosphate, 160 pounds.

The fertilizers were applied May 11. The crop was planted in drills three and one-half feet apart, May 17. The variety was Sibley's Pride of the North.

The soil throughout the season was too wet for the best growth of the corn crop. The crop was harvested on September 6, and put into the silo. The yield was as follows:

* For a full discussion of this subject see Dr. Goessmann's paper in the annual report of the Hatch Experiment Station for 1897, pages 222 and 223.

north plot, 5,760 pounds; south plot, 5,255 pounds. The difference is too small to afford a basis for a positive judgment as to the merits of the two forms of potash applied.

Fertilizers for Garden Crops.

In 1891 Dr. Goessmann began a series of experiments for the comparison of sulphate of ammonia, nitrate of soda and dried blood as sources of nitrogen for various garden crops. Sulphate of potash was employed to furnish potash. In 1892 the scope of the experiment was enlarged by including three additional plots, comparing the same materials as sources of nitrogen with muriate of potash used as a source of potash. The results of these experiments are fully discussed in Dr. Goessmann's reports. The following table shows the different fertilizers applied to the several plots: —

Plots.	Annual Supply of Manurial Substances.	Pounds.
Plot 1,	Sulplate of ammonia,	38
	Muriate of potash,	30
	Dissolved bone-black,	40
Plot 2,	Nitrate of soda,	47
	Muriate of potash,	30
	Dissolved bone-black,	40
Plot 3,	Dried blood,	75
	Muriate of potash,	30
	Dissolved bone-black,	40
Plot 4,	Sulphate of ammonia,	38
	Sulphate of potash,	30
	Dissolved bone-black,	40
Plot 5,	Nitrate of soda,	47
	Sulphate of potash,	30
	Dissolved bone-black,	40
Plot 6,	Dried blood,	75
	Sulphate of potash,	30
	Dissolved bone-black,	40

The area of the plots is about one-eighth of an acre each. The fertilizers used supply at the rates per acre: phosphoric acid, 50.4 pounds; nitrogen, 60 pounds; potash, 120 pounds.

The crops raised during the past year were garden peas, beets, squashes and celery.

Garden Peas. — The land was ploughed April 19, fertilizers applied and harrowed in April 21, and the seed planted on April 22. On June 7 it was noticed that the growth of the vines on Plot 1 was distinctly inferior to that on the other plots, and it so continued throughout the season. The pods produced by the vines upon this plot were short, but well filled, as were they also upon Plot 4. The growth of vines upon plots 3 and 6 may be characterized as medium; upon plots 2 and 5 the growth was rank. The pods upon these two plots were large, but not well filled. Three pickings of peas were made. The yield of green peas, as well as of vines, is shown in the following table: —

Green Peas (Pounds).

DATE.	MURIATE OF POTASH.			SULPHATE OF POTASH.		
	Plot 1.	Plot 2.	Plot 3.	Plot 4.	Plot 5.	Plot 6.
July 12, ...	100	93	99½	165	179	195
July 19, ...	66	150	132	143	134	91
July 23, ...	11	60	49	40	30	21
	177	203	280½	348	343	307

Green Vines (Pounds).

July 23, ...	102½	210	240	240	205	180

The average yield of green peas produced by the different fertilizers is shown in the following table: —

	Pounds.
Average of muriate plots, ...	220⅛
Average of sulphate plots, ...	332⅔
Average of sulphate of ammonia plots, . . .	262½
Average of nitrate of soda plots, ...	273
Average of dried blood plots, ...	293¾

It will be noticed that the sulphate of potash appeared to be distinctly superior to the muriate, that the dried blood gives a larger crop than either of the other sources of nitro-

gen, but that there is not a great difference between the three materials used to supply this element. The best crop is produced where sulphate of ammonia and sulphate of potash are used. The crop where nitrate of soda and sulphate of potash are used is not, however, materially inferior.

Beets. — The variety raised was the Eclipse. Fertilizers were applied as stated above, seed planted April 22, vacancies filled May 20. The growth of the beets upon Plot 1 was noticed early in the season to be distinctly inferior to that on the other plots, and before the close of the season most of the plants upon this plot were dead. On July 27 the crop was harvested. The yield of the several plots was as follows: Plot 1, 133 pounds; Plot 2, 711 pounds; Plot 3, 358 pounds; Plot 4, 448 pounds; Plot 5, 793½ pounds; Plot 6, 478 pounds.

The averages of the different fertilizers are shown below: —

	Pounds.
Average of muriate plots,	400⅔
Average of sulphate plots,	573⅙
Average of sulphate of ammonia plots,	290½
Average of nitrate of soda plots,	752¼
Average of dried blood plots,	418

It will be noticed that the sulphate of potash appears to be greatly superior to the muriate, and nitrate of soda is far ahead of sulphate of ammonia as a source of nitrogen for this crop. The best yield is produced where nitrate of soda and sulphate of potash are used together.

Squashes and Celery. — Both of these crops were failures, on account of the unfavorable weather. The celery plants, it is true, lived, but many of them made no growth. The plants were cut close to the ground on October 18, many of them being, if anything, smaller than when set. The cuttings were weighed, with the following results: Plot 1, 28½ pounds; Plot 2, 57 pounds; Plot 3, 35½ pounds; Plot 4, 28 pounds; Plot 5, 92 pounds; Plot 6, 24 pounds.

It is noticeable that here again Plot 5, where nitrate of soda and sulphate of potash were used, is the best; but even this did not produce a crop with any marketable value.

Injurious Effect of Sulphate of Ammonia and Muriate of Potash used together. — Particular attention is called to the fact that upon Plot 1, where sulphate of ammonia and muriate of potash are used together, the growth was, in the case of the peas and beets, decidedly inferior to that upon the other plots. This inferiority may undoubtedly be ascribed to the poisonous effect of the chloride of ammonia formed where these fertilizers are used together, to which Dr. Goessmann has called especial attention.

Experiments on Grass Land.

The system of manuring grass lands, planned by Dr. Goessmann and described by him in previous reports, has been continued. According to this system, the land receives one year a dressing of barn-yard manure at the rate of 8 tons per acre; the next year, wood ashes at the rate of 1 ton per acre; and the third year, ground bone 600 pounds, and muriate of potash 200 pounds, per acre.

Plot 1, which this year received ashes, gave a yield at the rate of 5,775 pounds of hay and 3,204 pounds of rowen per acre, — a total of 4 tons 979 pounds. Plot 2, which received manure applied in the fall of 1896, produced at the rate of 5,784 pounds of hay and 2,627 pounds of rowen per acre, — a total of 4 tons and 411 pounds. Plot 3, which this year received bone and potash, produced at the rate of 6,183 pounds of hay and 2,755 pounds of rowen per acre, — a total of 4 tons 938 pounds.

This system of using these different manures for grass lands in rotation has much to recommend it. It is simple, and has certainly given remarkably good crops. I believe, however, that the system would be improved by the use of a little nitrate of soda, say 150 pounds per acre, with the ashes as well as with the bone and potash.

Experiments with Nitragin, a Germ Fertilizer.

Nitragin, prepared according to the directions of Professor Nobbe, was imported at my suggestion from Germany in the summer of 1896. The material was fully described

by Dr. Goessmann in our last annual report, and full directions for its use are quoted by him.

The nitragin has been tried in accordance with directions, as stated elsewhere in this report, upon crimson clover and alfalfa, without apparent benefit. It has also been tried upon common red clover. On this crop, as with the others, no difference in growth attributable to the nitragin has been noticed; and, so far as can be judged at the present time, the use of this germ fertilizer for our common clovers is not to be advised. Nitragin undoubtedly contains the germs of the appropriate nodular bacteria, — the name of Professor Nobbe is sufficient guarantee of this. The failure of the material to benefit the crop appears to be due to the fact that our soils contain the nodular bacteria of the common leguminous crops in sufficient numbers so that the addition of a few more by the use of nitragin counts for nothing. Experience in the open field in most parts of Germany and England has been similar to our own, and I believe that we may safely conclude that only when we are about to begin the culture of a leguminous crop new to a particular locality will it be found advantageous to employ nitragin. In such cases the soil lacks the appropriate nodular bacteria; nitragin furnishes these, and the result is a better growth, because the crop is enabled to make use of the free nitrogen of the air from the first, which it could not do in the absence of the proper bacteria.

Sulphate of Iron as a Fertilizer.

Sulphate of iron has been tried during the past season upon the same plots as in 1896, but this year with corn as a crop. The sulphate of iron is used at the rate of 80 pounds per acre. The crop where it was employed was a little inferior to that on the plots where it was not used. Without sulphate of iron the average yield of the plots was $58\frac{1}{4}$ pounds of corn and $163\frac{1}{4}$ pounds of stover; with sulphate of iron, $50\frac{3}{4}$ pounds of corn and 160 pounds of stover.

Variety Tests.

1. Corn.

Twenty of the more promising varieties of corn tried for the first time last year have been given a further trial during the past season. Nine of these varieties were flint corns, as follows, named in the order of productiveness: Sanford, Longfellow, Waushakum, Giant Long White, Rhode Island White Cap, Early Canada, King Philip, Angel of Midnight, Compton's Early. The varieties of dent corn, named in order of productiveness, were Early Butler, Leaming Field, Champion White Pearl, Queen of the Prairie, Iowa Gold Mine, King of the Earlies, Sibley's Pride of the North, South Dakota White, Huron Extra Early, Wisconsin Yellow and White Cap Yellow.

Varieties the ears of which were very moist when husked are Queen of the Prairie and Huron Extra Early. Varieties which were moist are White Cap Dent, Leaming Field, Iowa Gold Mine and Champion White Pearl.

All of the varieties in these two classes are too late for culture as grain crops in this locality, though they would do for the silo.

2. Potatoes.

Eighty-one varieties of potatoes were cultivated for purposes of comparison upon the general plan described in our last report (ninth). The soil was a well-drained medium loam. The fertilizers used per acre were as follows: —

	Pounds.
Nitrate of soda,	240
Acid phosphate,	400
Sulphate of potash (high grade),	250
Tankage,	240
Dried blood,	100

These materials were mixed and scattered broadly in the furrows before dropping the seed. The seed was planted April 30. May 5 the crop was somewhat injured by washing of the soil between the rows and by the excessive rainfall. The potatoes were dug September 26 to October 6. The yield was at the rate of from 115.7 to 282.4 bushels per acre. The eleven largest yields of merchantable tubers,

in the order of productiveness, were given by the following varieties: Rose No. 9, Restaurant, Woodbury's White, Bliss's Triumph, Prolific Rose, Empire State, Early Maine, Dakota Red, Sir William, Early Rose and Beauty of Hebron. All of these gave a product at the rate of more than 220 bushels of merchantable tubers per acre. Again, as last year, we find the two old standard sorts, Early Rose and Beauty of Hebron, ranking among the very best. It appears doubtful whether any among all those tried are truly superior to these varieties.

Twenty-three varieties have given yields of merchantable tubers at the rate of less than 175 bushels per acre. These, in the order of inferiority, are the following: Minister, Bill Nye, Harbinger, Peerless, Jr., Livingston Banner, Burpee's Extra Early, Carmen No. 3, Dandy, Early Market, Crown Jewel, Merriman, White Star, Irish Daisy, Chance, Six Weeks, Alliance, Sunlit Star, World's Fair, Freeman, Ohio, Jr., Great Divide, Wise Seedling and Early Norther.

All of the varieties grown this year are to be examined for determination of dry matter and starch, but this work could not be completed in season for this report. Full details as to the varieties cultivated are therefore reserved until these analytical results can be published.

3. Grasses.

Sixty species and varieties of grasses have been under trial. Most of them occupied plots containing one square rod. About one-half of these grasses were sown in the spring of 1896. Among those so sown the following varieties winter-killed: English rye grass, Italian rye grass, crested dog's-tail and meadow fescue. Among comparatively little-cultivated varieties which appear promising may be mentioned the following: tall oat grass, tall fescue, red fescue, fowl meadow, Canada blue-grass, water-spear grass and wood-meadow grass.

The yield of the dry matter in the hay and rowen (where any was secured) of those varieties sown in the spring of 1896 during the past season, with date of cutting of both

the first and the second crops, is shown in the following table. The area in each variety was one square rod.

KINDS.	Date of cutting Hay.	Dry Matter in Hay (Pounds).	Date of cutting Rowen.	Dry Matter in Rowen (Pounds).
Timothy (*Phleum pratensis*), .	July 1,	19.36	Sept. 11,	6.44
Awnless Broom (*Bromus inermis*),	June 25,	14.71	Sept. 11,	6.44
Yellow Oat (*Avena flavescens*), .	July 1,	–	Sept. 11,	4.41
Sweet Vernal (*Anthoxanthum odoratum*).	June 4,	2.98	Sept. 11,	4.41
Meadow Foxtail (*Alopecurus pratensis*).	May 17,	5.70	June 25,	7.87
Red-top (*Agrostis vulgaris*), . .	July 6,	31.12	Sept. 11,	8.44
Rhode Island Bent (*Agrostis Canina*).	July 6,	30.81	Sept. 11,	6.41
Fall Oat (*Arrhenatheum avenaceum*).	June 25,	22.85	Sept. 11,	11.86
Glyceria fluitans, ...	July 1,	–	Sept. 11,	–
Meadow soft (*Holcus lanatus*), .	June 25,	10.25	Sept. 11,	6.42
Slender Fescue (*Festuca tennuifolia*).	June 15,	21.43	–	–
Meadow Fescue (*Festuca pratensis*).	Sept. 11,	4.36	–	–
Sheep's Fescue (*Festuca ovina*), .	June 15,	27.85	Sept. 11,	6.61
Tall Fescue (*Festuca elatior*), .	June 25,,	27.20	Sept. 11,	17.81
Hard Fescue (*Festuca durinscula*),	June 15,	27.42	Sept. 11,	–
Orchard (*Dactylis glomerata*), .	June 15,	16.41	Sept. 11,	11.96
Red Fescue (*Festuca rubra*), .	June 25,	27.47	Sept. 11,	–
Fowl Meadow (*Poa serotina*), .	July 6,	43.00	Sept. 11,	14.27
Rough-stalked Meadow (*Poa trivialis*).	July 1,	9.87	Sept. 11,	–
Kentucky Blue (*Poa pratensis*), .	June 15,	14.73	Sept. 11,	18.93
Canada Blue (*Poa compressa*), .	July 10,	43.68	Sept. 11,	6.17
Water Spear (*Poa aquatica*), .	July 1,	31.97	Sept. 11,	8.04
Canary Reed (*Phalaris arundinaria*).	June 25,	23.18	Sept. 11,	21.09
Wood Meadow (*Poa nemoralis*), .	July 1,	31.07	Sept. 11,	12.88
Creeping Rent (*Agrostis stolonifera*).	July 6,	15.27	Sept. 11,	–

4. Millets.

Twenty-one varieties of millet, occupying one square rod each, were grown for purposes of comparison on medium loam, manured at the rate of 600 pounds of ground bone and 200 pounds of muriate of potash per acre. These were of three species, *Panicum crus galli*, *P. miliaceum* and *P. italicum*. The varieties grown, with particulars concerning amount of seed sown, date of heading, height of plants, and the weight per plot and acre of hay produced, are shown in the table below: —

KINDS.	Ounces Seed Sown.	Date of Heading.	Date When Cut.	Height of Plants (Feet).	Weight, Air Dry, Square Rod (Pounds).	Weight per Acre (Pounds).
Panicum crus galli.						
Japanese barn-yard,	1	Aug. 2,	Aug. 17,	6	65	10,400
Japanese barn-yard, loose headed.	1	Aug. 2,	Aug. 17,	6	63	10,080
Panicum miliaceum.						
Common broom corn,	3	July 19,	Aug. 2,	4	51	8,160
Japanese broom corn, red seed,	3	Aug. 2,	Aug. 21,	4 -6	83	13,280
Japanese broom corn, white seed.	5	Aug. 10,	Aug. 29,	5½-6	92	14,720
California,	4	July 19,	Aug. 2,	4	62	9,920
Chinese,	4	July 23,	Aug. 5,	4	69	11,040
French,	4	July 23,	Aug. 5,	4	66	10,560
White French,	4	July 19,	Aug. 2,	3½-4	65	10,400
Red French,	4	July 19,	Aug. 2,	-	65	10,400
Hog,	4	July 19,	Aug. 2,	3 -3½	63	10,080
Panicum italicum.						
Canary bird seed,	4	Aug. 7,	Aug. 2,	-	40	6,400
Dakota,	4	July 23,	Aug. 12,	3½-4	60	9,600
Early Harvest,	4	July 19,	Aug. 2,	3 -3½	57½	9,340
Golden,	3	Aug. 21,	Sept. 4,	5	100	16,000
Golden Wonder,	4	Aug. 10,	Sept. 4,	5	95	15,200
Japanese Glutenous Hokkaido,	3	Aug. 12,	Aug. 26,	4½	63	10,080
Japanese Glutenous Mukoda-mashi.	3	-	Sept. 15,	2 -4	100	16,000
Japanese common Millet,	3	Aug. 12,	Aug. 26,	4¾	88	14,080
New Siberian,	4	July 28,	Aug. 12,	3 -4	55	8,800

The differences in yield are large, but the scale upon which the varieties were grown is small, — too small, in my judgment, to justify sweeping conclusions as to the relative merits of the several sorts.

The "Dakota" closely resembles the "Early Harvest;" the "loose-headed" variety of the "barn-yard" millet is much less leafy and less valuable than the common form. The so-called "Golden Wonder" cultivated appeared to be like the "Golden." The "Japanese Glutenous," from "*Mukodamashi*," is very late, and does not mature with us. The variety of glutenous millet from *Hokkaido* appears to be a valuable sort. Moisture tests which are being made will very likely change the relative position of some varieties.

5. *Japanese Millets for Seed.*

A small area of each of our three leading varieties of Japanese millets was grown for seed. The soil was fertilized for each variety at the following rate per acre, the fertilizer being sown broadcast and harrowed in: —

Manure,	4 cords.
Nitrate of soda,	125 pounds.
Dried blood,	100 "
Tankage,	200 "
Superphosphate,	250 "
Muriate of potash,	200 "

The season was not very favorable for these crops, and they were somewhat injured on several occasions by the washing of the soil, due to excessive rain-fall.

Barn-yard Variety (*Panicum crus galli*). — The area sown to this variety was .633 acres. The seed was sown May 27, in drills, and was cultivated and hand-weeded. It yielded 1,370 pounds of seed and 4,360 pounds of straw, which is at the rate of 40 bushels of seed and 3 tons 888 pounds of straw per acre.

Japanese Broom-corn Millet (*Panicum miliaceum*). — The area of this variety was .248 acres. It was planted and cultivated like the preceding variety. The yield was 535 pounds of seed and 1,620 pounds of straw, which is at

the rate of 40 bushels of seed and 3 tons 532 pounds of straw per acre.

Japanese Millet (*Panicum italicum*). — The area of this variety was .138 acres. It was planted and managed in all respects like the preceding varieties. The yield was 305 pounds of seed and 519 pounds of straw, which is at the rate of 41 bushels of seed and 1 ton 1,761 pounds of straw per acre.

6. *Soya Beans.*

A small area of each of the three leading varieties of Japanese soya beans was cultivated for seed. The yield was at the following rates per acre: early white, 18.7 bushels; medium black, 16 bushels; medium green, 34.5 bushels. The last-named variety thus once more demonstrates its great superiority as a crop-producer over either of the other sorts under trial.

7. *Clovers.*

Tests were begun in 1895 for the purpose of comparing four of our prominent clovers, viz., medium red, mammoth, alsike and crimson. The result of the first year's test will be found in our ninth annual report (pages 27 to 29). As stated in that report, our results indicate that the crimson will not prove valuable as a fodder crop in this locality.

Medium Red Clover. — The crop of this variety compared very favorably with that of the mammoth clover in the season of 1896, but during the winter of 1896 and 97 the plants of this variety were nearly all killed. The plots were accordingly ploughed and sown with oats and vetch.

Mammoth Clover. — This variety was somewhat injured by the winter, but was allowed to stand. Bad weather prevented its being harvested at the proper time, and it was much damaged before it could be secured. It yielded at the rate of about 1½ tons per acre at the first cutting. The second growth was much mixed with weeds. It was cut and weighed green, yielding at the rate of about 2,800 pounds per acre.

Alsike Clover. — This variety, like the preceding, was much injured by rain. It, like the mammoth, was found to have suffered much during the winter. The crop cut was

much mixed with weeds, yielding at the rate of $2\frac{1}{4}$ tons per acre for the first cutting. The second growth was mostly weeds, and was weighed green, amounting to about 5 tons per acre.

Conclusion. — The mammoth clover under the conditions of our experiment has shown greater vitality and productive capacity than either of the other sorts. It is worthy more extensive cultivation.

Sulphate v. Muriate of Potash for Clovers. — As stated in our ninth annual report, there were two plots of each of the varieties of clover under comparison, one fertilized with muriate of potash, the other with sulphate of potash. The results in 1896 showed no material difference in yields which could certainly be ascribed to the nature of the potash salts used. The same is true this year.

The sulphate plots, both of the mammoth and the alsike clovers, yielded most at the first cutting; the muriate plots, in both cases, yielded most at the second cutting; but, as stated, the crops secured at the second cutting were largely mixed with weeds. The results, therefore, must be regarded as without especial significance.

8. *Sweet Clover* (*Melilotus alba*).

This crop occupied two plots of two-fifteenths of an acre each, in Field B. The same crop was grown upon these plots in 1896, and the results are fully discussed in our ninth annual report. The growth during that season was for the most part small and unsatisfactory, owing apparently to the fact that the appropriate nodular bacteria were not present in sufficient numbers to enable the crop to make use of free atmospheric nitrogen. A few of the plants in 1896 were found to have abundant nodules upon their roots. These showed a deep-green color and made a vigorous growth. It was judged that, if the land should be thoroughly worked in various directions, the nodular bacteria would be scattered throughout the soil, and that the second crop upon the same land would be better than the first. The soil was accordingly thoroughly prepared, and the seed for the crop of this year sown at the rate of 10 pounds per acre on July 30, 1896.

The growth was very much superior to that of the previous year, and upon examination in the early part of the season it was found that the roots of about one-half the plants were abundantly supplied with nodules. These plants were making a vigorous growth, and had a deep-green color, indicative of an abundant supply of nitrogen. They were at this time evidently able to draw upon the atmosphere for this element. Later the other plants in the field seemed also to gain this ability.

On July 8 the crop averaged 6 feet in height. A portion was cut and fed to the cows kept in the department of foods and feeding. This portion yielded at the rate of about 12½ tons per acre. Dr. Lindsey reports that the cows ate it readily and appeared to be fond of it. It was, however, rather coarse for feeding when allowed to stand until the latter part of July. If to be fed, the crop should be cut early. In average seasons it would be at its best condition during the first half of the month of July. It is not, however, as a fodder crop that I am inclined to recommend a trial of sweet clover, but rather as a crop for green manuring. I believe it may serve here a similar purpose to that served by crimson clover in localities where it is hardy.

Miscellaneous Crops.

Alfalfa. — One-quarter of an acre of light soil was sown on April 17 with alfalfa. The fertilizer applied to the quarter acre was as follows: fine-ground bone, 100 pounds; nitrate of soda, 50 pounds; phosphatic slag, 50 pounds; muriate of potash, 50 pounds. One-half the seed used was treated with nitragin. All the seed germinated quickly, no difference being noticed between the treated and the untreated. The small plants were, however, injured by the heavy rains, and up to date the crop has made but a feeble growth.

Saccaline. — Our trial of this crop has been carried out upon two small plots, the one having a heavy, moist soil, the other a light, drier soil. One-year-old plants were set in the spring of 1896. The growth during that season was feeble. In August of that year each plot was given a good

dressing of manure. In the spring of 1897 it was found that a considerable number of the plants had been winter-killed. On the heavy soil 36 out of 408, and on the lighter soil 71 out of 129, were dead; of 451 plants left in a nursery, 258 were dead. Plants which lived through the winter were well started by April 20, but the new growth was killed by a frost. On July 16 the growth, which ranged from 1 to 7 feet in height, the average being about 3 feet, was cut. The plants were large and woody. The yield on the heavy soil, 408 plants, was 295 pounds; on the lighter soil, 129 plants, 132 pounds. The leaves only were eaten by cows, — horses would not eat it at all. A second crop was not cut, but on October 1, when the plants were killed by frost, the second growth averaged about 18 inches in height. As a result of our trial of this crop, I am convinced that it is without value as a fodder crop for us.

Crimson Clover. — A further trial of this crop has been made upon a rather light soil. The seed was sown July 3 with equal parts of winter rye. Nitragin, not received in season to apply with the seed, was mixed with water, according to directions, and applied to the clover August 31, the plants then standing about 2 inches high. The crop was a complete failure, every plant being winter-killed.

Winter Vetch. — A small plot of this crop has been grown upon a light soil. It was sown August 20, equal parts of vetch and rye. This vetch proved perfectly hardy and grew vigorously, reaching a greater height than the rye. This vetch will prove valuable as a green fodder when sown with winter rye.

Besides the above, we have cultivated a few rows each of a large variety of fodder plants, some 39 in number. In this variety are included a large number that have been mentioned in previous reports, and they do not require further notice at this time.

Among those cultivated for the first time this year are the *Idaho field or coffee pea* (*Cicer arietinum*). This appears to be the same as the gram or chick pea, which we have had under cultivation for two years. The growth is too small to make it valuable for a fodder crop.

Another new fodder crop for this year was the *Brazilian stooling flour corn.* The plants made a vigorous growth, but are judged to be too coarse and woody to prove of much value for fodder.

Black chaff or African millet is another crop under trial this year for the first time. It appears to be the same as Kaffir corn, and, as reported last year, our experience leads us to regard this fodder crop as inferior to maize for our climate.

A Reputed Method for Destroying Stumps.

A correspondent in one of our agricultural papers during the summer of 1895 reported that he had found it possible to destroy stumps in the following manner: —

A hole one or two inches in diameter according to the size of the tree, and eighteen inches deep, is to be bored in the stump. Into this put from one and one-half to two ounces of saltpetre, fill with water and plug tightly. Six months later, put into the same hole about one gill of kerosene oil, and set fire to it. The correspondent stated: "The stump will smoulder away without blazing, even down to every part of the roots, leaving nothing but ashes."

On Nov. 4, 1895, fifty stumps of trees cut in 1894, including the following varieties, maple, hickory, hemlock, white pine, yellow birch and elm, were bored according to directions. On December 11 saltpetre and water were put into the holes, according to directions, and the holes plugged. During July, 1896, the plugs were removed, the holes were filled with kerosene, and an attempt made to burn the stumps. It was found that not even the oil would burn. A portion of the stumps were left until June, 1897, when another attempt was made to burn them, using a low-test oil, called paraffine gas oil. The stumps are still in the field. The method has been given a thorough trial, but must be regarded as a complete failure.

Poultry Experiments.

Experiments with poultry were carried out during the winter of 1896 and 1897. Our attention was confined to three points: —

1. Effect upon egg-production of the use of condition powders.

2. Comparative value for egg-production of dry-ground animal meal and cut fresh bone.

3. Comparative value for egg-production of cut clover and fresh cabbage.

General Conditions.

In all of these experiments pullets purchased in Plymouth County and sent to us in December were used. A few had laid before we received them, and production was stopped by the move, as is generally the case. Some of the pullets moulted after reception here, which served to reduce the egg yield. Each of the six lots of fowls occupied a house, with roosting and laying room ten by twelve feet, and scratching shed eight by twelve feet in size. Each had the liberty of a large yard, which furnished a little grass after April 15, but in all alike. Each of the feeding trials began January 1 and continued until May 2, — 122 days.

Soft foods were mixed for the morning mash with boiling water the night before using. Sufficient of the materials for a fortnight were mixed dry at one time. Oats were always scattered in the straw in the shed at noon. At night the wheat was fed in the same manner. As a rule, a little cut bone was fed once a week, in place of the noon ration of oats. About twice a week cabbage was hung up in each coop except the one where cut clover was under comparison with this vegetable. Clear water, shells and grit were before the fowls all the time. Occasionally salt was added to the morning mash. At the conclusion of the experiment the dressed fowls were sent to G. M. Austin & Son, Boston, who reported upon the quality of the several lots.

1. Effect of Condition Powder upon Egg-production.

This experiment was carried out in most respects in the same manner as last year. Light Brahmas were selected for this test, 20 in the coop receiving condition powders and 19 in the other. The food of the two lots was the same

in kind, with the exception that the fowls in House No. 6 received daily condition powder in the morning mash, in accordance with directions furnished with the powder.

The kinds and amounts of food used are shown in the table: —

KINDS.	AMOUNTS (POUNDS).	
	No Condition Powder.	Condition Powder.
Wheat,	209	220
Oats,	150	150
Bran,	27	28
Middlings,	27	28
Animal meal,	27	28
Clover,	27	28
Cabbage,	28	29
Corn meal,	28	29¼
Bones,	9	9

About three pounds of condition powders were used in the experiment.

The weights of the fowls were taken at intervals, and were as follows: —

Average Weights (Pounds).

	No Condition Powder.	Condition Powder.
January 4,	4.868	4.650
February 4,	5.260	4.950
March 9,	5.360	5.343
April 26,	5.310	5.470
May 3 (after fasting twelve hours),	5.160	5.180
Dressed weight,	4.605	4.657

The results and leading details are shown below: —

Condition Powder for Egg-production.

Experiment January 1 to May 2.	Number of Hen Days.	Gross Cost of Food.	Cost per Hen Day.	Cost of Food per Egg.	Number of Eggs.	Weight of Eggs.		Weight per Egg (Ounces).
						lbs.	oz.	
No condition powder,	2,318	$6 61	$0 00285	$0 0124	532	65	1½	1.958
Condition powder, .	2,354	6 68	00280	0125	540	67	4	1.993

The nutritive ratio was 1 : 5.16 for the fowls not receiving condition powder; for the others, 1 : 5.14,—practically identical. The total dry matter in food consumed for each egg produced was: without condition powder, 0.8349 pounds; with powder, 0.8688 pounds. Besides the perfect eggs as shown in above table, the fowls receiving no condition powders laid three soft-shelled eggs; the others, one. There were five sitters in the first lot, eleven in the second.

Samples of the eggs were analyzed, and those from the condition-powder fowls were found somewhat richer in dry matter, protein and fat. The eggs were also tested in two families by careful house-keepers. The reports did not agree in all particulars; but one of the two found the eggs from the fowls which had received condition powders superior in flavor of yolk, flavor of white, in beating qualities and in consistency; the eggs from the other fowls better in color and size of yolks. The other reported the condition-powder eggs strong in flavor and the yolks small. This discrepancy is probably to be accounted for from the fact that the number tested was small. Individual as well as class differences would almost certainly be found in the eggs.

The fowls which had received condition powder were reported as dressing rather better than the other lot.

One fowl in the condition-powder house died during the test; there were no losses in the other house.

In conclusion, I have to say that the differences found in this experiment are too small to be considered decisive. On the side of the condition powder we have size of eggs and

weight and quality of the dressed fowls; against the powder, we have the food cost per egg, the weight of dry matter in food per egg, and the loss of one fowl. We are warranted simply in the statement that the powder does not appear to have paid for its use.

2. Cut Bone v. Animal Meal for Egg-production.

Each of the two houses contained twenty Plymouth Rock pullets in this experiment. The bone and animal meal were each mixed in the morning mash. The foods used are shown below: —

KINDS.	Cut-bone House (Pounds).	Animal-meal House (Pounds).
Wheat,	213	196
Oats,	149	149
Bran,	27	28
Middlings,	27	28
Buffalo gluten,	–	28
Animal meal,	–	28
Clover,	28	27
Cabbages,	26½	29½
Chicago gluten,	27	–
Cut bone,	28	–

The nutritive ratios in the two houses were 1 : 5.05 and 1 : 4.45 respectively.

The average weights of the fowls were as follows: —

	Cut-bone House (Pounds).	Animal-meal House (Pounds).
January 4,	4.75	4.89
February 6,	5.10	5.00
March 9,	5.86	5.28
April 27,	5.44	5.15
May 3 (after fasting twelve hours),	5.28	4.88
Dressed weight,	4.83	4.43

The dressed fowls which had received the cut bone were reported slightly better than the other lot. The leading details and results are shown in the following table: —

Cut Bone v. Animal Meal.

Experiment January 1 to May 2.	Number Hen Days.	Gross Cost of Food.	Cost per Hen Day.	Cost of Food per Egg.	Number of Eggs.	Weight of Eggs.		Weight per Egg (Ounces).
						lbs.	oz.	
Cut-bone house, .	2,279	$6 61	$0 0028	$0 0130	508	64	9	2.0034
Animal-meal house, .	2,440	6 24	0025	0097	639	80	15	2.0270

There was, in addition to the eggs as shown by the table, one soft-shelled egg in each house. Two hens in the cut-bone house died during the experiment, from diarrhœa; those in the other house were healthy throughout the experiment.

The dry matter per egg was, where cut bone was fed, 0.877 pounds; on animal meal, 0.69 pounds. The number of sitters was 6 in the cut-bone house, 12 in the other.

A sample of eggs from each house was subjected to analysis. Those produced on the cut bone contained rather more protein but less fat than the other. A test for cooking quality was indecisive; one of the two house-keepers having preferred one lot; the other the opposite lot.

The advantage in this trial is, then, clearly with the animal meal as a food for egg-production. It has given more eggs of a greater average weight and at considerably less cost than the bone; and it is, moreover, a more convenient food to use, as well as safer. The results this year are thus the opposite of those of last year. We have now repeated this experiment four times, with results twice favorable to the bone and twice to the animal meal, but have not before found so decisive a difference as this year. We repeat the experiment again this winter.

3. Clover Rowen v. Cabbage for Egg-production.

Plymouth Rock pullets were used in this experiment; but they were later-hatched fowls than those in the experiments already described. There were twenty fowls in each

of the two houses, at the beginning. One fowl died in each house during the experiment, from unknown causes. The cut clover was fed in the morning mash. Instead of the clover, a fresh cabbage was kept before the fowls in the other house.

The foods used are shown in the table : —

KIND.	Clover House (Pounds).	Cabbage House (Pounds).
Wheat,	223	212
Oats,	150	149½
Bran,	28	36
Middlings,	28	36
Animal meal,	28	34¾
Clover,	26	–
Cabbage,	–	46¾
Cut bone,	8½	8½
Oat meal,	28	36

The nutritive ratio was practically the same in both houses : viz., in the clover house, 1 : 4.99 ; in the other, 1 : 4.838.

The average weights of the fowls were as follows : —

DATES.	Clover House (Pounds).	Cabbage House (Pounds).
January 4,	4.560	4.530
February 4,	5.480	4.800
March 8,	5.420	5.350
April 27,	5.470	5.394
May 3 (after twelve hours fasting),	5.289	5.184
Dressed weights,	4.780	4.890

The leading results and details are shown in the table: —

Clover Rowen v. Cabbage for Egg-production.

Experiment January 1 to May 2.	Number of Hen Days.	Gross Cost of Food.	Cost per Hen Day.	Cost of Food per Egg.	Number of Eggs.	Weight of Eggs.		Weight per Egg (Ounces).
						lbs.	oz.	
Clover house, . .	2,356	$7 033	$0 0029	$0 0150	466	59	10	2.0472
Cabbage house, . .	2,423	6 988	0028	0118	588	75	1	1.9880

In addition to these, the fowls in each house laid one soft-shelled egg.

The advantage lies most decidedly with the fowls fed cabbages, in so far as numbers, weight and cost of eggs are concerned. The eggs from the clover house were, however, much superior in cooking and eating quality to those from the other. Both house-keepers reporting are most emphatic in the expression of their preference for the eggs from the fowls fed the clover. One reports: "The eggs from the clover lot are in every way superior." The other says: "They are superior in color, size of yolk and flavor;" and adds that "they have the finest flavor of any eggs" she ever ate.

Analysis showed the eggs from the fowls fed cabbages to contain higher percentages of dry matter, protein and fat than the others. The superior richness of these eggs apparently renders them strong in flavor.

REPORT OF THE METEOROLOGIST.

JOHN E. OSTRANDER.

The work of the meteorological department during the past year has been in the main a continuation of that of previous years, with such minor changes as, after due consideration, have seemed advisable. The observations for temperature are now all taken in the ground shelter on the campus. The publication of the maximum and minimum temperatures taken in the observatory shelter was discontinued last year, owing to their unreliable character. For the same reason, the observations themselves were discontinued early in April the present year.

The usual bulletins, giving a summary of the records and weather for each month, have been published. An annual summary will be issued as soon as the records for the year are completed.

No material additions have been made to the equipment of the department during the year.

Arrangements have been made to furnish the New England Weather Bureau with the weekly snow reports, as was done last year.

In co-operation with Professor Whitney of the Division of Soils, United States Department of Agriculture, this department installed one of his instruments (kindly loaned by the Department at Washington) for the electrical determination of moisture in the soil. Observations were taken from the latter part of June until early in November. The records, however, are incomplete for the period, owing to breaks in the circuit and other causes which made the instruments fail to work at times. The readings taken were sent weekly to the Department at Washington. The Division of Foods and Feeding of this station made some

independent determinations of moisture for standardizing the instrument, and the Division of Botany kept a record of the growth of the crops where the electrodes were buried. Owing to the unusually wet weather during the summer and the incomplete records of the instrument, the results of the experiment were not entirely satisfactory. The department expects to repeat the observations next year under more favorable conditions, and an outfit for that purpose has been ordered.

It is hoped that arrangements may be made to put the electrometer in the tower in working order, so that observations on atmospheric electricity may be undertaken.

REPORT OF THE BOTANISTS.

GEORGE E. STONE, RALPH E. SMITH.

Our work during the past year has been in general a continuation of that of the year preceding. In this, as in other departments of the station, the work falls under two classes: first, examination of material sent in for determination and answering of inquiries; second, investigations of problems connected with plant physiology and pathology.

For the purpose of investigation the greenhouse has been remodelled and enlarged during the past summer, so as to admit of carrying on experiments under more desirable conditions. It is quite essential, in experimenting with plants, that the number employed should be large enough to make it possible to draw deductions from the results with a reasonable degree of certainty that errors arising from individual variation have been counterbalanced. It is also essential that the heat, light and moisture conditions should be equal upon each series of plants under consideration, and that these conditions should compare as closely as possible with the best method of cultivation. In the construction of the experiment house these details have been considered as carefully as possible. The house as now arranged consists of several sections, in which different temperatures can be maintained, for growing tomatoes, cucumbers, lettuce and other important plants subject to destructive diseases. The amount of money invested in the production of greenhouse crops is large and continually increasing, and no small part of our work consists in the study of the various diseases which affect them.

For the last three years we have been investigating methods of controlling the gall-forming nematode worm, which affects cucumbers, tomatoes, English violets, roses, cyclam-

ens and many other greenhouse plants. The results of the investigation are nearly ready for publication, but it seems desirable to first clear up a few remaining points upon the habits of the worm, which are not well known.

Experiments are also being made upon the different methods of pruning tomatoes, and upon the best light conditions for assimilation in greenhouse cucumbers.

With regard to lettuce we are studying the mechanical conditions of the soil as affecting the crop, and the various fungous diseases to which it is subject, more especially the disease known as the "drop."

In addition to these experiments, it may be mentioned that there are incidentally being carried on investigations upon the influence of electrical currents on the growth of plants. Bulletin 43 of this station embodied the most careful and extensive series of experiments ever made upon the subject. They were carried out by Mr. Asa S. Kinney, while a student at the college, and did not necessarily fall under station work. The results obtained by him were of such a promising nature that it has seemed well worth our time to carry the investigation further. It should be stated that any costly method of using electricity as an accelerator of plant development is not to be recommended. If, however, any simple and cheap means of using electric currents can be used, which will give an acceleration in the growth of a crop equal to 30–40 per cent., it might be worthy of consideration by practical agriculturists.

We have in progress a series of experiments with various gaseous substances, with a view to developing a treatment of this sort for combating fungous diseases of greenhouse plants. This method of treatment has been suggested by the extensive application which it has reached in exterminating insects. While we are as yet unable to present any results of great practical value, it is hoped that these experiments may lead to the development of an effective treatment for greenhouse plant diseases by the use of a gaseous substance. The great superiority of such method over that of spraying, which is in many cases inapplicable, needs no exposition. Our experiments thus far have been carried on

with two gases, hydrocyanic and formaldehyde. Neither of these appears to answer the purpose. The former, which has been found to be of considerable value as an insecticide, cannot be made effective as a fungicide without using a strength which will prove fatal to the plant. This we have determined by parallel exposures of various fungous spores and plants to the gas, and also by the fact that spores of the carnation rust, taken from plants which had been almost killed by over-exposure, germinated freely. Formaldehyde has a well-marked fungicidal effect, and is much less harmful to plants; but we cannot at present recommend it as a general fungicide, on account of the difficulty of producing it in sufficient strength.

The past year has been an exceedingly abnormal one for vegetation, and as a result this division has had many inquiries concerning plant diseases, different from those of ordinary years. The excessive and long-protracted rains and the lack of sunshine gave rise to a multiplicity of plant diseases such as we have not had for some years. This was the case not only in regard to our various crop plants, but our introduced ornamental species and even our wild plants were unusually affected by fungi. An unusual number of the so-called spot diseases made their appearance, and defoliated to a greater or less extent more than one species of tree. These spot diseases were especially disastrous to the sycamore and butternut, both of which in many instances lost all their foliage; while other trees, such as the chestnut and wild cherry, were more or less affected. The fungi causing these diseases are not new to these trees in this locality, but the abnormal conditions to which all vegetation was subjected proved amply sufficient to accelerate their growth and development.

Whenever the normal conditions surrounding the plant are disturbed, we must expect to find irregularities in its functions; and any serious irregularities in the plant's functions are most likely to manifest themselves by the presence of some insect, fungous or bacterial organism. Abnormal functions, or, in other words, physiological disorders, are in a majority of instances the basis of many plant diseases

with which gardeners have to contend; and, since we are liable to observe only the effects of the fungus or bacteria preying upon the plant, we too often think that they are the primary causes of the disease, when, as a matter of fact, they are purely secondary.

This leads us to the subject of spraying as a preventive of plant diseases. From the hap-hazard manner in which it is often resorted to, one would gain the idea that it is intended as a curative rather than as a preventive remedy. This idea is erroneous, inasmuch as spraying is intended as a prevention rather than a cure. This misconception of the proper use of spraying solutions gives rise to the practice of using the Bordeaux mixture as a panacea for every plant disease. Upon this point we wish to state that it must be distinctly borne in mind that spraying under any condition is only a temporary means of preventing certain diseases. The ultimate aim of all progress connected with gardening should be not only to improve the marketable product, but to improve the stock and increase our knowledge pertaining to proper cultivation, so that spraying will be unnecessary. Many experienced gardeners recognize this, and we find experts in almost every line of gardening who have had eminent success in controlling diseases without resorting to the use of fungicides. Some of the most experienced growers of carnations claim that they can control the many diseases which have of late years affected this plant, by simple, judicious methods in the management of the greenhouse.

To expect that spraying is going to save plants that are improperly cared for, or to act as a cure for those already diseased, is absurd. There are many instances where spraying produces beneficial results, and at the present time it appears to be essential, in some instances, to the production of good crops; but there are also many instances where it is entirely useless. This applies especially to the diseases having their origin in improper care or in abnormal conditions surrounding the plant. The condition of the potato crop in Massachusetts during the past summer affords an illustration of how any amount of spraying would not save

it from disease, when the soil was soaked with water and the plants in some instances practically submerged for days at a time. Every plant is surrounded by a host of parasitic organisms, which, given the proper conditions, will manifest their distinctive properties. The healthy, vigorous plant is always less susceptible to the attacks of fungi than the weakly, abnormally developed one, — a fact which every practical gardener readily understands. We have seen this illustrated so many times in our work in the greenhouse that it may be well to give an example of it here. Certain species of non-parasitic nematode worms, which are always present in greenhouse soil, although apparently doing no harm as long as the plants are vigorous, will, as soon as the plant becomes weakened or abnormal from any cause, penetrate the tissues and cause rapid decomposition of the same. What is true in regard to nematodes applies also to fungi and bacteria, and, indeed, these various forms of organisms are most frequently to be found together in the decayed tissues of the plant.

Before any attempt is made to spray diseased plants, it is well worth while to find out something about the nature of the disease with which the plants are affected. It is, for example, unwise to spray roses for the black spot or mildew when the roots are half decayed by the action of parasitic gall-forming nematode worms; and for the same reason it would be unwise to treat the spot disease of the English violet, when the roots are covered with hundreds of minute galls, and when the supply of nutriment from the root is greatly interfered with.

On the other hand, spraying the apple, grape, potato and plum is at the present time justifiable and necessary; and there are many diseases common to greenhouse cucumbers and tomatoes which can be largely controlled by spraying, although it must be said here that by judicious management of the various conditions surrounding the plants these diseases can be checked.

The Causes of the Failure of the Potato Crop of 1897.

The disastrous effect upon agricultural crops of the excessive rainfall of the past season has been especially marked upon the potato. The small yield and large amount of rotting of this staple may be easily attributed to this source. In all sections of the State, as well as beyond our borders, the report has been general of a small potato crop and excessive rotting. This rotting has been generally regarded as resulting from the well-known and ordinary "potato rot" fungus, Phytophthora infestans. In fact, however, we have to describe a series and variety of agents, which, under the favorable influence of the excessive rainfall, — an influence unfavorable to the vitality of the plant, — have brought about the diminution and destruction of the crop.

At planting time the ground was extremely wet. The crop, however, started well, and the plants appeared above ground in a promising manner. Continuous rains kept the soil saturated with moisture, and before the plants had reached a height of more than six inches it was noticed in many places — usually the lowest and wettest portions of the field — that many of them were dying. Such plants did not collapse suddenly, but gradually turned yellow and faded away, most of them dying eventually, though here and there one would be seen which maintained a feeble, stunted growth through the season. This was the case not only in this vicinity, but it was also reported from various parts of the State.

Investigation of affected plants showed that the trouble was due to a rotting of the stem of the young plant below ground, which rotting evidently proceeded from the seed potato, which was found in every case to be a putrid mass, while the decay was gradually extending up the young stem. Careful search for the cause of the rotting failed to reveal any particular organism to which it could be ascribed. That it was of bacterial origin seemed quite certain, as the decayed tissue swarmed with organisms of this class, while no fungus which could be considered the cause of the rotting

was found. In the cortex and exterior portions of decayed stems several forms of Micrococcus and also other bacteria were found in abundance. In the interior portions a large, motionless bacillus occurred quite abundantly and exclusively, and may have been the primary cause of the rotting. The most probable explanation, however, seems to be that the normal functions of the plant were disturbed and its growth checked by the unusual amount of moisture in the soil. The seed potato, with its supply of reserve food material for the young plant thus left idle in the soil, naturally rotted away, and this rotting communicated itself more or less to the young stem proceeding from the "seed." The plant, not being in a condition of vigorous growth to resist this rotting, gradually succumbed to it, and in most cases died. The few plants, as mentioned above, which continued a feeble growth through the season, accomplished this by throwing out roots above the rotted portion of the stem, and thus prolonged a feeble existence. Such plants produced no tubers, and consequently had no value whatever.

This, then, was the first of the troubles affecting the potato crop in this section. We do not describe or consider it as a specific "disease" of the potato, nor do we deem it necessary to consider any treatment for it. We at first recommended removing affected plants, but doubt now if such a course would have been of any considerable practical value. We are inclined to believe that the trouble was not brought about by any specific or especially destructive organism, but was simply the result of the unusual meteorological conditions of the season, and under such conditions could not be prevented from occurring by any means at our command.

By July 1, most of the plants which had fallen a prey to the above disease were withered away and dead, while those which had escaped had made a fairly good growth and nearly reached maturity in point of size. About July 15 several hot, sunny days came on, following a long very rainy spell. In many potato fields on low ground the plants began to wilt and die down. In a large field at the college, situated on a long slope, the plants at the top were un-

affected, but those in a limited area at the bottom of the slope — the wettest part of the field — began to wilt (see plate). Many had already died here from the effects of the first disease. It is a well-known fact that plants often wilt when exposed to strong sunlight after a continued cloudy and wet period, this being due to excessive evaporation or transpiration of water from the leaves. In this case, however, the wilting was too pronounced to be attributed to this simple physiological phenomenon. Investigation showed that the leaves were not "blighted" nor were they affected in any way except the simple wilting, which was evidently caused by some trouble at the root. Plants were then dug in various portions of the affected area, and in all stages of collapse, and their roots examined for the cause of the trouble. It was found that there was no one organism (except possibly bacteria) attacking the plant, but there was a general rotting, resulting from the wet condition of the soil and consequent low vitality of the plant. The features of this rotting varied greatly in different plants, however, and scarcely any two were affected in an exactly similar manner, it being almost impossible to specify a feature of the disease common to all, except the wilting of the tops. In the very wettest part of the affected area the tubers were rotting badly. These rotten tubers were swarming with bacteria, but they were of various kinds, and to no one could be ascribed the beginning of the trouble. Various species of fungi were found in some, but these were moulds and similar forms, and included nothing which by any probability could have caused the rotting. Since fungi were entirely absent in many of the rotten tubers, it is certain that they did not cause the trouble. In many cases the decay seemed to have started where a grub of some kind had eaten into the potato. On somewhat dryer ground, where the plants wilted, the tubers were not rotten. In many cases, however, the stem was found to be decayed just where it joins the root. The young rootlets were also rotting, so that the cortex fell away from the central portion. These symptoms also occurred, and more pronouncedly, in cases where the tubers were rotten. In

these decayed stems and roots no one organism could be found as the cause of the rotting. Bacteria (mostly micrococcus) swarmed in all affected parts, and several mould fungi also occurred. Quite noticeable on all affected plants was the occurrence on tubers and even on the base of the stem, of small, white, mealy dots, scattered abundantly over the surface. These were apparently enlarged lenticels, being composed of parenchymal cells breaking out at the surface. It seems probable, or is at least possible, that their production was due to the scarcity of air in the wet soil.

We can only conclude here, as in the other case, that this cannot be called a definite disease, but rather was the result of abnormal and unusual conditions. During the long-continued rain the living functions of the plant were disturbed and its growth checked. Various organisms then came in, and, gaining a foothold, so weakened it that when the sun came out it wilted down and in the worst cases died. Had it been possible to thoroughly cultivate and stir the soil at this time, it is reasonable to suppose that much of the trouble might have been averted; but the extreme wetness made such a course impossible.

This trouble came on after the potatoes had reached a marketable size. We therefore recommended digging them in all affected places, in order to save them from decay. Beyond this there could be no practical treatment suggested.

Early in August, or even sooner, the real potato blight or rot, Phytophthora infestans, began to appear, and developed very extensively during the month, killing the tops of potatoes everywhere, and causing great loss by rotting of the tubers. This disease is too well known to need extended description. Its ravages might probably have been controlled to some extent by thorough spraying throughout the season, but it would have been practically impossible to entirely prevent it in such a summer.

The "Drop" of Lettuce.

The loss represented by this disease frequently amounts to thousands of dollars in a single season in Massachusetts. Almost every lettuce grower has had more or less experi-

ence with it, although, as with every other disease, some have been much more affected than others. We have known several instances during the season where extensive growers have lost practically their whole crop, and, as a consequence, have become much discouraged with lettuce growing. Inasmuch as the general characteristics of this disease were given in the ninth annual report, it is not necessary to enter upon any minute description here. Suffice it to say that the disease makes its appearance in the stem, close to the surface of the ground, where the tissue becomes slimy and soft, and eventually the whole stem at this point disintegrates and collapses. This occurs most frequently just as the plants reach maturity.

The fungus causing this disease is well known to all greenhouse men. The "damping fungus" (Botrytis), which causes the drop, often gives rise to disastrous effects on begonia and other cuttings in the propagating pit. The fungus, however, as it appears upon the lettuce, presents some aspects which are different from its appearance upon cuttings, and reaches a more advanced stage of development. Our present knowledge in this direction possesses more of a technical than practical interest, although an understanding of the complete life history of the fungus will, no doubt, lend much aid to its rational treatment.

The natural conditions governing the development of the organism appear to be similar to those of most organisms, — that is, it requires the presence of oxygen. It is well known that almost any object when driven into the ground will undergo disintegration much more rapidly at the surface of the soil, for here the conditions of moisture, etc., are most favorable for the organisms producing disintegration. And so it is with the "drop" fungus; it finds just the conditions at the surface of the soil, under the moist, shady leaves of the mature lettuce plants, for its destructive work.

Our experiments upon the control of this fungus are by no means complete, but it will not be out of place here to offer some suggestions in regard to its general habits and the methods of treatment which may be tried. Probably

every grower has the germs of the disease in his lettuce soil to a greater or less extent, but the conditions giving rise to their excessive development are not always present. Some claim that manure is the principal source of infection; yet, on the other hand, while all use manure, all are not troubled in the same degree. As a remedy for the drop, some have resorted to the practice of sanding the surface of the soil or putting on a layer of yellow loam. This is for the purpose of giving a clean, uninfested surface to the soil surrounding the plants. In regard to the effect of this treatment, it may be stated that opinions differ considerably. Whether the method of applying a superficial layer of sand or subsoil to the surface will be of any assistance in keeping the drop in check appears somewhat doubtful, from an experiment made of burying some infested plants to a depth of three or four inches in a pot of yellow loam subsoil. It was found that the fungus made its way to the top in a very few days, as was evident from the mould-like growth of the mycelium upon the surface of the soil and the death by drop of plants which had been set in the pot. Neither can we expect much from the application of chemicals, as any such treatment would interfere with the growth of the plant, and hence become objectionable. Some experiments are now being made with gases, with the idea of killing the organism by fumigation; but this method does not promise much success.

The application of live steam to the soil, and thus sterilizing it, would undoubtedly destroy the germs of the disease. To do this would necessitate laying two-inch tile at a depth of eight inches or a foot below the surface of the soil, and at a distance of one or two feet apart, and driving in steam under pressure and allowing the same to permeate the soil. This method can be employed on a small scale with good results, but the larger area of a lettuce house would render its practical application uncertain. Another method of treatment by steam, which would be far cheaper, would be to sterilize the surface of the soil to a depth of three or four inches or more. This can be done by constructing a pit in the lettuce house and covering the bottom

with tile or one and one-half or two inch steam piping. The tile allows the steam to escape very readily; and, in order to get the best effect, they should be laid close together, say one foot, or less. In case steam pipes are used, — and they are probably more effective than tile, — they should be bored with holes every three or four inches, to allow the steam to escape. With an arrangement of this kind, one would be able to sterilize the soil in a few hours. A pit twenty feet long, ten feet wide and eighteen inches deep would hold sufficient soil to cover twelve hundred square feet of surface three inches deep. The time required to heat this earth up to 200° F. would be only a few hours. Of course the pressure of steam available, the closeness of the pipes and the number of outlets for the steam would largely determine the time necessary to heat the earth.

Various methods of treatment for this disease are being tried, to determine how it may be most effectually dealt with. In connection with the method of steam sterilization, which seems by far the most promising, it is especially desirable to ascertain just how deep the soil must be sterilized in order to keep down the fungus.

The Asparagus Rust.

(*Puccinia asparagi.* D. C.)

In the last annual report of this division attention was called to a new disease which had appeared upon the asparagus, and the apprehension expressed that it might come to be a serious matter. That apprehension has been more than justified. The asparagus rust, unknown to the growers of Massachusetts in 1895, slightly prevalent in 1896, has appeared everywhere during the past season, and bids fair to become a most important factor in the growing of this crop.

The disease first appeared in the fall of 1896, both in this State and in several others, but was not generally prevalent at that time, although in some fields it was very abundant. Cutting and burning infested tops was generally recommended and to some extent practiced; but the majority of asparagus growers had not as yet become acquainted with this new danger menacing their crops.

This rust, like the well-known one of the wheat, has three different stages or forms in its development, though in this case they are all developed upon the asparagus plant, while in the other, one form comes upon the barberry bush and the other two upon the wheat and other grains and grasses. When first noticed in 1896, the asparagus rust was in the fall stage, the black rust or *teleuto* stage, the earlier stages not having attracted attention. In 1897 many asparagus fields were found to be affected as early as July 1, and by August the complaint was general throughout the asparagus-growing sections of the State. It was now the red rust, or *uredo* form, which was present, being followed again in the fall by the black form. Apparently almost every field of asparagus in the State was affected before the end of the season. The rust in most cases appeared first on young beds, — which was natural to expect, since the stalks were not being continually cut off as they appeared. In the older beds, from which the stalks were being cut for market, little or no rust appeared until well into July or August, after cutting had been suspended and the tops allowed to develop. In most cases, however, they were soon affected as badly as any. The effect of the rusting was that the tops lost their green color, and turned brown and died prematurely. Mr. George P. Davis of Bedford says in regard to his beds: "The twenty-sixth of July the tops were all turned brown, and looked as though a fire had swept over the field. There was no green to be seen. . . . In handling the tops a fine dust which looked like smoke was quite noticeable." This dust consisted of countless numbers of the spores of the fungus.

The first attempts at checking the rust were made in the fall of 1896, and consisted of cutting and burning affected tops. When the disease appeared so extensively in 1897, many growers cut the tops in August, when they had become badly rusted. It is impossible to say with much certainty what the result of the first cutting (fall of 1896) may have been, inasmuch as comparatively few beds were thus treated or badly affected at that time. A good-sized bed at the college was considerably rusted, and the tops

were cut and burned late in the fall. The bed was well cultivated and fertilized, and no rust appeared upon it in 1897 (that is, not enough to be noticeable) until well into the fall, when the black rust stage was quite as abundant as it had been in 1896. Mr. S. T. Davis of Orleans also mentions having observed a small bed, which was cut in the fall of 1896, upon which no rust appeared in 1897. Whether the cutting of the tops or some other factor kept down the rust in these beds, we are not prepared to say. The cutting which was quite extensively practiced in the summer of 1897 seems to have been entirely without effect, as the rust appeared again just as badly on the second growth.

The experience of another season is necessary to demonstrate the actual effect and seriousness of this disease. Its perennial occurrence to the extent of the past season could not fail to have a disastrous effect upon the asparagus-growing industry. It is not the sort of disease which is effectually suppressed by spraying methods, though something of that sort may be developed if it becomes necessary.* It should be remembered, however, that the past season was an unusually favorable one for all fungous diseases, and consequently it may have developed much more extensively than it ordinarily would. If it could be mostly confined to its teleuto or black rust stage, which appears in the fall when the plants have practically completed their growth, it is not probable that any serious injury would result. At all events, the effect of the great prevalence of the rust in 1897 upon the asparagus crop of 1898 will be awaited with great interest by all interested in its cultivation.

The Fire Blight.

(*Micrococcus amylovirus.*)

This disease of the pear, quince, apple and other pomaceous trees has been the subject of frequent inquiry during the past season. It ordinarily causes the most damage on the pear and quince, and is one of the most destructive of plant

* Recent experiments indicate some amenability of the rust to spraying, although not more than twenty-five per cent. reduction is claimed.

diseases. The trouble appears in the branches, sometimes a whole limb of considerable size, but more often the smaller terminal twigs, being affected. These portions of the tree suddenly wilt and die, the leaves and young fruit turning black and hanging to the branches, producing the characteristic scorched appearance which gives the disease its name. It spreads rapidly about an orchard and increases from year to year, often involving the entire tree and causing its death if left unrestricted.

The cause of this trouble was long a matter of speculation, but it is now known to be a species of bacteria which gains access to the tissues of the tree and by its rapid multiplication therein causes great destruction. This disease cannot be reached by spraying, and the only remedy consists in severely cutting back all affected branches, or whole trees if badly affected. All such prunings should then be destroyed by burning. This cutting should be done whenever the disease is observed, but is especially advisable in the fall or late summer, when the trees should be carefully examined, to make sure that no diseased branches or twigs are left to perpetuate the disease over winter. As the disease affects the hawthorne (Cratægus), shad bush (Amelanchier) and mountain ash (Pirus Americana), as well as the cultivated fruits, it may spread from some of these wild trees to the latter, unless care is taken to prevent such contagion. It is not probable, however, that such infection is ordinarily at all extensive.

The Quince Rust.

(*Gymnosporangium clavipes* C. and P.)

The numerous inquiries which we have received during the past season concerning this not uncommon trouble, as well as our own observations, indicate that it has been unusually prevalent and destructive. The disease affects principally the fruit, but also the young wood, causing distortion and malformation in both cases. It is very conspicuous upon the affected quinces in midsummer, both from their distorted shape, and from the numerous white, tubular excrescences appearing upon their surface. These excres-

cences contain masses of the bright orange-yellow colored spores of the fungus which causes the disease. The fungus has a peculiar course of development. It not only exists in the form seen upon the quince, but has also another form or stage, living upon a different kind of plant and quite different in appearance. This stage of the fungus lives upon the red and white cedar and the juniper, and is one of the forms which produce upon those plants the abnormal growths popularly known as "cedar apples." These cedar apples are peculiar outgrowths upon the twigs of cedars and junipers, reaching their complete development in early spring. They are oftentimes regarded as the proper product of the tree, or as insect galls, — which ideas are equally incorrect. These growths begin to form in midsummer, developing as small excrescences upon the twigs and gradually increasing in size until winter, when they are nearly full grown. An "apple" consists at this stage of an abnormal mass of the cells of the tree, with the filaments of the fungus growing abundantly between them. Remaining thus over winter, the first warm, moist weather of spring starts it into further growth and development. Upon the surface of the affected wood numerous projections appear, of a conical shape, and composed of a yellow, gelatinous substance. These projections are composed of a mass of the fungous filaments and a gelatinous substance which they secrete. In them are produced the spores of this, the *teleuto* stage. These spores are composed of two cells and borne on long stalks. The sudden appearance of these peculiar growths on cedar trees just after a spring rain is often taken for the blossoming of the tree, but is in reality the fructification of the fungus parasitic upon it. The gelatinous appendages of the cedar "apples" soon dry up and wither away after the rain, but not until the teleuto spores contained in them have germinated and produced secondary reproductive bodies called *sporidia*. These are carried away in the air, and proceed to infect, not cedar trees, but quinces or one or two other related plants. Upon the surface of these they germinate and produce filaments which grow into the substance of the young fruit or stems, and by their presence there cause the

distortion in shape seen in affected specimens. Upon this host the fungus forms little pustules just beneath the surface, finally breaking out into the air as tubular projections. In these are formed the yellow spores of this stage, called *æcidia*. These spores are unable to infest quinces again, but upon cedar trees begin the development of a new generation of "apples," which will in turn produce teleuto spores the following spring.

Treatment. — It is not often that the damage caused by this disease is of great extent. Sometimes, however, it becomes sufficiently troublesome to make it worth while to attempt to repress it. It is evident that the most vulnerable point of the fungus causing the trouble lies in its inability to reproduce itself continuously upon the quince. The most direct method of treatment, therefore, is to exterminate all white and red cedars and junipers from the vicinity of the orchard, and cut off all affected parts of the fruit trees, or entirely destroy badly affected ones. This, for various reasons, however, may not always be possible or desirable. As to spraying methods, it has been found quite effective to spray with Bordeaux mixture two or three times during the spring, especially during or just after rainy weather, when the spores are being disseminated. It may also be possible sometimes to remove affected twigs of cedar and juniper trees before the spores have been produced.

This same fungus has also been unusually abundant during the past season upon the fruit of various species of Cratægus (hawthorne), accompanied by an equal abundance of the closely related species, Gymnosporangium globosum, upon the leaves. We have also noticed these or related species upon the fruit of the Japanese quince (Cydonia Japonica) and mountain ash (Pirus Americana).

The Brown Rot of Stone Fruits.

(*Monilia fructigena.* Pers.)

This well-known disease found in the past summer just the conditions suited to its best development, and the peach, plum and cherry crops suffered in consequence. The dis-

case needs no description to those who have ever tried to raise any of the above-mentioned fruits. It appears in the summer, some time after the fruit has set, often just as it comes to maturity, or even earlier in the season, the time of its appearance depending a great deal upon the weather, a warm, rainy period being liable to bring it on at any time. Indeed, it does not always wait for the production of fruit upon which to make its attacks, but often develops upon the blossoms, causing them to abort, and spreading thence into the young twigs upon which they are borne, results in their death. Upon the fruit the rotting is almost always found to some extent at the time of ripening, and, as already mentioned, often occurs earlier in the season when the weather is favorable, i. e., warm and moist. At such times the greater part of the crop is sometimes destroyed. In cherries the chief damage is done upon the ripe fruit. In peaches and plums, which have a longer season of ripening, the young fruit is more frequently affected. Early peaches are considered more susceptible to the disease than the later varieties.

The cause of this disease is a mould-like fungus (a true parasite, nevertheless), which spreads its vegetative filaments through the affected fruit and thus causes its decay. Wet weather brings about the rotting of the fruit by favoring the growth of the fungus, not by its direct effect. Fruit which is affected begins to discolor and soften, and gradually dries up and shrivels into a shrunken mass about the stone. It often remains on the tree for months, especially in the peach. In the early stages of infection the surface becomes covered over with little grayish spots of a powdery, dusty nature. These are clusters of the spores of the fungus, produced in countless numbers on the ends of filaments from the inside of the fruit which have pushed out through the surface. These spores, which serve to reproduce the fungus, are extremely minute in size, so that *en masse* they appear as a fine dust. Being easily carried by the wind, they are spread far and wide, and may thus infect a large district in a few days, under favorable conditions. After becoming dry and hard the affected fruits cease producing

spores, but their period of harmfulness is not yet ended. After lying over winter in a dormant state, the fungus in them is again aroused to life by the warm rains of spring, and begins the production of spores which are ready to infect the crop about to be produced.

It has been thought practicable by some to exterminate or at least greatly reduce this disease by the destruction of all affected fruit and thus prevent the fungus from surviving through the winter. The variety of fruits upon which it can exist, however, and the practical hopelessness of accomplishing the destruction of any considerable proportion of it, together with the uncertainty of the fungus being altogether dependent upon the dormant stage found in the dried-up fruit for its existence over winter, make the success of this plan very doubtful. We would not, however, discourage the practice of removing and destroying the affected fruit, especially any remaining upon the trees over winter; for this may result in future decrease of the rotting, especially in isolated orchards or trees.

The usual methods of orchard spraying have been found to keep this disease in check to a considerable extent, though in favorable weather it will often sweep through an orchard, despite all precautions. The spraying should be begun early, and kept up through the season with considerable frequency, especially near the time when the fruit is maturing. For such spraying, Professor Maynard recommends the use of the ammoniacal copper carbonate or a weak solution of copper sulphate. Details in regard to the treatment of this disease may be found in Bulletin 44 of this station.

The Chrysanthemum Rust.

(*Puccinia Tanaceti*, S.)

In the last annual report a rust upon chrysanthemum leaves was described, this being, as far as known, the first published mention of such a disease. The specimens were sent by Mr. G. H. Hastings of Fitchburg, who had experienced heavy loss as the result of the rust. This was the only occurrence of the disease encountered during 1896.

This year it has appeared in many places, both in this and other States, occasioning considerable loss, as it is often very destructive to infected plants. It is not yet generally known, however, among those who cultivate the chrysanthemum, though we fear that it may be by another year. Judging from the history of many similar diseases (asparagus rust, carnation rust, hollyhock rust, etc.), it will not be surprising if a general epidemic of this disease occurs next year. It will be well worth while, therefore, for growers to take precautions for guarding against it as much as possible, especially those whose stock is already infected. Great care should be exercised to get cuttings from vigorous plants, unaffected by the rust; and it will no doubt be profitable in the end to spray them a few times during the summer with the Bordeaux mixture or potassium sulphide, using one ounce of the latter in two gallons of water, or stronger, if the leaves will stand it. Should the rust appear on the young plants, they should certainly be sprayed at once and at frequent intervals thereafter, and the affected plants removed and destroyed. It will be useless to try to save them as they are doomed to destruction, or at best will only attain a weak, sickly, worthless growth. When the plants are placed in the benches for the fall, great care should be taken that no rusty specimen goes in, else it may bring about the ruin of the entire lot. Further than these suggestions little more can be said about the disease until time shall have shown what its seriousness may be and to what extent it can be controlled.

There are several other diseases affecting the leaves of the chrysanthemum, so that some may be in doubt whether their plants are really infested with the rust. It causes discoloration of the leaves, like other less destructive diseases, but may be distinguished from them by its production of small pustules, of a dark-red, powdery substance, on the under side of the leaves, something as in the carnation rust. This red powder consists of the spores of the fungus, which reproduce and disseminate it.

A Disease of the Cultivated Geranium.

During the past summer there appeared upon the leaves of some geranium plants upon the college grounds a disease which appears to be different from anything heretofore described. The plants in question grew in a long border bed, and comprised several different varieties. Along the back edge of the bed, trees and low shrubbery hung over to a considerable extent, so that the plants in that portion were quite shaded, while those in front were exposed more directly to the sun. The disease came on in the latter part of July, during the rainy weather then prevailing. The leaves began to turn yellow in small spots, which gradually increased in size, the leaf tissue dying away at those points; thus the leaves soon became covered with dead spots of considerable size, and finally lost their vitality completely. The plants in the front of the bed were most affected, those in the shaded portion showing little or none of the disease. All varieties, as above mentioned, were equally affected. The plants were sprayed with the Bordeaux mixture, but with no apparent success. The same disease was brought to our notice in Northampton and also in the eastern part of the State.

The trouble appeared to be the result of the attack of some fungus, but investigation of the affected leaves failed to reveal any such organism. Neither was there any evidence of the presence of insects. Numerous bacteria, however, were found in all affected tissue, and appeared to be the cause of the spotting of the leaves. We do not consider this a genuine disease of the geranium, nor do we expect to find it occurring in the future. That the plants were in a condition of low vitality and hindered growth by reason of the excessive moisture, and hence were an easy prey to organisms which ordinarily would be unable to affect them, seems the most probable explanation. The futility of spraying to prevent such a disease becomes apparent when its real nature is revealed.

Some Leaf Blights of Native Trees.

During the past season several different kinds of trees have been so generally affected with certain leaf-attacking fungi as to become almost entirely defoliated before the end

of the summer. While of no great economic or practical importance, these attacks have been so marked and their effects so conspicuous that a brief description of the nature of the trouble may be of interest. The following diseases were generally prevalent wherever the host trees occurred, over the considerable portion of New England which we visited during the summer.

A Leaf Blight of the Sycamore or Buttonwood.

(*Glocosporium nerviscquum* Fckl. Sacc.)

Numerous inquiries reached us during the spring and early summer concerning the very prevalent and destructive blighting of the leaves of the sycamore tree (*Platanus occidentalis*). It is probable that every good-sized tree of this species in the State was attacked by the disease. The younger trees were apparently, for some unexplained reason, less susceptible. The trouble appeared in May, when the trees, which had just leaved out, appeared as if they had been nipped by a frost or scorched by fire. The leaves withered and turned brown, the new twigs were killed and many of the leaves fell to the ground. In this condition the trees lost all beauty, and became unsightly objects. This disease is not entirely new in this State, although it has never been so generally prevalent before. It was first described in Germany in 1848, and has been common in various parts of Europe since then. In this country it has occurred mostly within the last fifteen years. It first appeared in the District of Columbia, Ohio, Kentucky and other parts of the country south of here, but is now widespread.

The cause of this disease is a parasitic fungus, growing in the leaves and young twigs of the tree, and causing their death. Several other fungi are usually found in connection with the disease, and may have something to do in causing it. This disease is a very serious drain upon the vitality of the tree, and often results in its death. Its occurrence early in the season, however, favors the tree, since it has a chance to, and in fact does, produce a new crop of foliage to carry it through the season. This exhausts the tree, however, and if repeated for several seasons is likely to cause its death.

As to a remedy for this disease, there is little to say. Spraying with fungicides is not to be practically considered, on account of the size and small economic importance of the tree. Gathering and burning diseased branches and leaves might lessen the trouble somewhat; but, if the disease continues to prevail, it will probably be best in the end to dispense with the sycamore as an ornamental tree, and plant something else instead.

A Leaf Blight of the Butternut.

(*Glocosporium Juglandis* (Lib.) Mont.)

No fungous disease has been more noticeable throughout the State during the past season than this. It first became apparent in July, when butternut trees were noticed to be losing their foliage. Examination showed that the rapidly falling leaflets were covered with dead and discolored spots, and had lost their vitality. All trees were not affected in the same degree, as some were almost completely defoliated in August, while others were attacked later or lost their leaves more slowly. By October 1, however, it was almost or quite impossible to find a butternut tree which had not lost the greater part of its leaves.

The cause of the trouble is a fungus, which lives in spots in the leaf, killing the tissue at these points and gradually causing the death of the whole leaflet, so that it falls to the ground. The disease spreads rapidly from leaf to leaf and from tree to tree, and many trees are soon defoliated. It is a well-known fungus, but has been unusually abundant this year.

A Leaf Spot of the Chestnut.

(*Septoria ochroleuca* (B. and C.)

This is another disease, quite similar to those above described, which has been very prevalent this year. It first became noticeable in July, when the ground under chestnut trees was covered with fallen leaves. Upon these leaves the fungus manifested itself very prominently in small, round, dead spots, about one-eighth of an inch in diameter, scattered over the surface more or less abundantly. These spots are the points where the fungus has become estab-

lished and killed the tissue. The fungus, like all those causing these diseases, reproduces itself by spores, which are produced in minute cavities in the dead area, usually on the under side of the leaf. Almost all the leaves on affected trees become dotted over with the little dead spots, and most of them fall to the ground before their time, thus weakening the tree. The disease is not, however, an especially destructive one, except to the beauty of the tree.

A Leaf Spot of the Wild Black Cherry.

(*Septoria cerasina*, Pk.)

The well-known "shot-hole" fungus, which often causes extensive damage to the plum and cherry, has been exceedingly abundant this year upon the leaves of the wild black cherry (*Prunus serotina*), many trees being almost entirely leafless in August. This fungus attacks the leaves of plums and cherries of several species, producing dead spots upon them, and eventually causing their death. In connection with the wild cherry the disease has little economic importance, except as it may spread from that tree to cultivated species. On this account, the destruction of the wild cherry, so desirable for the repression of the black knot and tent caterpillar, is even more advisable.

BACTERIAL BLIGHT OF GERANIUM

QUINCE.

REPORT OF THE HORTICULTURIST.

SAMUEL T. MAYNARD.

The lines of work in this division the past season have been largely the same as for 1896.

Raspberry Seedlings.

The collection of raspberry seedlings, now three years old, produced a large crop of fruit the past season, and many most promising varieties were found among them. These seedlings were from the hybrid or purple-cap variety *Shaffer*. They produced a great variety of forms, from the black-cap type (*Rubus occidentalis*), the hybrid type of the parent, to some of the most beautiful forms of the red raspberry (*Rubus strigosus*) and to albino forms of both species. Careful records of the hardiness of cane, vigor of growth, time of ripening, productiveness and quality were made during the season, and at this time the plantation is a very handsome one.

Another collection of seedlings from the same source, but one year younger, also shows many interesting forms of growth.

Seedling Currants.

About three hundred seedling currant bushes two years old have made a good growth and show many interesting varieties.

Grape Seedlings.

The collection of seedling grapes, numbering some six hundred varieties, is very interesting. The growth has been very vigorous and healthy, and most of them are in a condition to yield enough fruit next season to determine some-

thing of their value. From the appearance of the foliage and the growth of vine we may look for a great variety of types of fruit.

Strawberry Seedlings.

This collection, numbering about four hundred varieties, is in a very fine condition, and some varieties have shown decided merits.

Named Kinds of Strawberries.

Many new varieties of strawberries of decided merit have been added to the collection. Many of the older varieties of little merit have been discarded, and the plots at this time never looked so well.

Strawberry Field.

The field crop is planted on the knoll south of the old farm buildings, and is in a remarkably good condition. This land is of a gravelly nature, but with a retentive subsoil of hardpan, which in an ordinarily moist season may be depended upon to produce a large crop of fruit, but in a very dry time suffers severely. The land slopes in such a manner that either the trench system or the spraying systems of irrigation or sub-irrigation can be employed in case of drought. Two reservoirs on the grounds are available for this purpose, and the three methods may be comparatively tested. A considerable quantity of two and one-half and two inch pipe on hand is available for this work. This need not be of any great expense, while its importance is very great, as no comparative results have ever been obtained that show whether any of the methods can be profitably employed, or which is the most valuable.

Variety Testing.

The value of the comparative tests of varieties of fruits, vegetables, flowers, etc., is often discussed. That it is a legitimate and important part of the work of the stations is shown in the demand made for the publications recording the results of such tests. When we consider the large number

of new varieties of fruits, vegetables, etc., offered to the public every year at high prices, with the claim of merits for them far above those of the standard sorts, and which the average grower cannot afford to buy and test, it is certain that the stations can save the people much loss and expense.

In the work of variety testing at this station in past years, the reports show that the new varieties reported as being the most valuable have been those that later were considered most valuable and were most largely grown by the commercial grower, while the varieties reported as having little or no value have been everywhere soon discarded by the growers who tested them. This work would be of much greater value, without doubt, if one or more sub-stations in different parts of the State could be established, where the same varieties could be tested under different conditions of soil and exposure.

The large number of new varieties of all kinds of fruit, vegetables, etc., being introduced every year, and generally with extravagant claims of merit, renders this work of the Experiment Station imperative, and the people should refuse to purchase such varieties until they have the endorsement of the stations of several States. A single season's trial of a variety is of very little value. It requires several years, at least, to prove the value of vegetables or even the more early maturing small fruits, while tree fruits require a much longer period.

Other Experiments.

Among the other experiments now under way may be mentioned the destruction of greenhouse insects by the use of hydrocyanic acid; the testing of the value and keeping qualities of some fifty-five varieties of celery; sub-irrigation in growing lettuce under glass; the use of different kinds of mulch for strawberries; methods of overcoming the asparagus rust; testing varieties of dwarf Lima beans, etc.

Reports will soon be made of the results of the variety tests of fruits, vegetables, etc.; the use of "Laurel Green" as an insecticide and fungicide; of arsenate of lead as an insecticide; and of other work done during the year.

REPORT OF THE CHEMIST.

DIVISION OF FOODS AND FEEDING.

J. B. Lindsey.
Assistants, E. B. Holland, F. W. Mossman, B. K. Jones, H. H. Roper.

Part I. — Laboratory Work.

Outline of Year's Work.

Part II. — Feeding Experiments and Dairy Studies.

Part I.

Extent of Chemical Work.

The work of the chemical laboratory connected with this department has very materially increased during the past year. There have been tested 150 samples of water, 197 samples of milk, 2 samples of oleomargarine, 1 sample of butter, 123 samples of miscellaneous substances. In addition to the above, which were sent to the station for examination, there have been analyzed 260 samples of milk and 388 samples of feed stuffs, in connection with experiments in progress by this and other divisions of the station, making a total of 1,147 substances which have passed through the laboratory within twelve months. There have also been carried on, for the Association of Official Agricultural Chemists, chemical investigations, relative to the meth-

ods best adapted for the estimation of starch in agricultural products. This has involved a great amount of chemical work, the extent of which it is impossible to express in mere figures.

Character of Chemical Work.

Water. — The analyses of water have been made by the same methods as heretofore, and with the same end in view, namely, to aid farmers and others in guarding against the danger arising from the use of waters coming from polluted springs and wells. Illness frequently occurs in the family, the cause of which it is often difficult to explain, until an examination of the water reveals its pollution with sink, privy, stable or other drainage. The waters tested show much the same condition as in former years; in round numbers, 15 per cent. could be pronounced excellent, 40 per cent. fair, 25 per cent. suspicious and 20 per cent. dangerous for drinking. Fully 50 per cent., therefore, were considered of a suspicious character. Three samples were found to contain lead, and had been known to have produced lead poisoning. We can only repeat the advice given in former years, in cautioning all who are obliged to depend upon wells and springs for their water supply to take every precaution to prevent any drainage from entering, and to keep the grounds about the well or spring free from all objectionable matter. Lead pipes should never be used to draw water through, especially if the water is free from mineral matter (soft).

Milk. — The most of the milk received at the station has been sent by farmers who ship their milk to Boston contractors. They had probably been notified by the contractors that their milk was below the Massachusetts standard,* and they wished to ascertain its exact quality, and what, if anything, could be done for its improvement. The larger part of this milk was found to contain 12 to 12.5 per cent. of solids and from 3.25 to 3.50 per cent. of fat, and was in all probability the unadulterated product of the cow. The contractor, however, because of the large amount of milk

* The Massachusetts standard calls for 13 per cent. solids and 3.70 per cent. fat, excepting during April, May, June, July and August, when but 12 per cent. solids and 3 per cent. fat are required.

offered, can afford to be particular, and desires only that up to, or above the legal standard. In such cases there is nothing for the farmer to do but to add some grade Jersey or Guernsey cows to his herd. It certainly would be a long step forward, if milk were sold not simply as milk, but with a guarantee of composition. Milk containing 11.5 per cent. solids and 3 per cent. of fat should surely bring less per quart than milk containing 12, 13 or 14 per cent. solids, and 3.25, 4 or 5 per cent. fat.

Cattle Feeds.—At its session of 1897, the State Legislature passed a law authorizing the inspection of feed stuffs. The work is being carried out by this department, and it is hoped that it will result in keeping out poor and adulterated material, and in keeping the regular articles of as constant a composition as possible. Considerable adulterated cotton-seed meal was found on the market during the early spring months. This material consisted of a mixture of hulls and meal, the former ground very fine in order to conceal its identity. The adulterated product contained from 22 to 30 per cent. of protein, while a prime meal should show from 40 to 45 per cent. Farmers were warned through the agricultural and daily papers of the presence of the adulterated article, and cautioned against its purchase. The result of this has been to produce a feeling of uncertainty and to restrict the use of the genuine article. To overcome this, the American Cotton Oil Company have placed a guarantee of composition upon every bag put out by them. It is hoped other manufacturers will follow this example. *Farmers should by all means give the preference to the guaranteed article.*

Other new feed stuffs are those put out by the H. O. Company, under the name of dairy, horse and poultry feeds. The feeding values of these feeds are being investigated. Varieties of oat feeds, being mixtures of oat hulls with more or less corn meal, are found in the market without name or guarantee. Farmers are cautioned against their purchase, for the reason that the price asked is, as a rule, considerably in excess of their feeding value.

Methods for the Determination of Starch.—The work undertaken for the Association of Official Chemists, already

alluded to, has been reported to them. While more work will be done along this line, it has been quite clearly demonstrated that the so-called Maercker and Reinke methods for the estimation of starch in agricultural products are faulty, and will give altogether too high results. The only method from which reasonably accurate results may be expected is the diastase or malt method,* and this method has been adopted by the official chemists in place of all others.

Part II.

Experiments with Pigs.

Two experiments have been completed with pigs, and a third is now near completion. These experiments were designed to study the value of corn meal as compared with hominy and cerealine feeds for pork production, when fed in combination with skim-milk. Both these feeds are quite similar in composition. They consist of the hull, germ and more or less bran and starch removed from white corn, during the preparation of cracked hominy and cerealine flakes for human consumption. Cerealine is much more bulky than the hominy feed. These experiments will be published in detail later. It can be said, however, that pigs have made nearly, and in some cases fully, as good growth on these feeds as on an equal amount of corn meal.

Salt Marsh Hay.

A thorough investigation has been completed concerning the general character and feeding value of salt marsh hay. The results are being published in bulletin form. The practical conclusions, briefly stated, are as follows: —

The several varieties of salt hay have, ton for ton, from 10 to 17 per cent. less feeding value than average English hay. When 10 to 12 pounds of salt hay were fed daily, together with 7 or 8 pounds of grain and a bushel of ensilage, the ration produced within 2 to 5 per cent. as much milk and

* Sachsse's method can be used for estimating starch in commercial starch and in potatoes.

butter as an equal amount of English hay similarly combined.

Because of the less market value of salt as compared with English hay, rations containing the salt hay, as given above, produced milk and butter from 10 to 20 per cent. less than did rations containing English hay. No objectionable flavor was noticed when the salt hay was fed directly after milking.

It is undoubtedly wise for farmers living near the salt marshes to feed salt hay and sell English hay. For the results in detail, and a fuller discussion, see the bulletin.

Digestion Experiments.

During the past year we have studied the amount of actual nutriment in salt hays, to which reference has already been made, in a number of new by-products and in green crops for soiling. Many of our results, together with practical conclusions therefrom, will soon be ready for publication.

COTTON-SEED FEED AS A HAY SUBSTITUTE FOR MILCH COWS.

J. B. LINDSEY, E. B. HOLLAND AND B. K. JONES.

The Experiment concisely described.

What Cotton-seed Feed is. — The seeds of the cotton plant are irregular, egg-shaped in form, and almost hidden by a tuft of white fibre which covers their surface. The meat of the seed is covered with a thick, tough hull of a black color. Machines have been invented to remove this hull, and the meat is subjected to warm pressure for the purpose of removing as much as possible of the oil. The pressed meat or cake is ground, and results in the decorticated, bright yellow cotton-seed meal of commerce. The black hull, covered with the white fibre, was formerly almost entirely used as fuel, and the ashes were sold for fertilizing purposes. Of late many southern farmers, at the recommendation of experiment stations in the south, have been mixing these hulls with the cotton-seed meal and feeding them to beef and dairy cattle, with very good success. Within the last few years this material, under the name of *cotton-seed feed*, has been offered in our Massachusetts markets. The manufacturers claim that the feed consists of 1,600 pounds of hull and 400 pounds of meal, thoroughly mixed by machinery. The price charged has been $13 per ton in car lots, delivered in Massachusetts, which would be equivalent to at least $15 in single tons. The feed, shipped in bags, is quite bulky, and, because of the white fibre covering the hull, looks somewhat like wool waste. Its color is light yellow, due to the admixture of the cotton-seed meal.

The Experiments briefly stated.

The experiment station has conducted four experiments with this feed, two with milch cows and two with sheep.

The feed for the first experiment was furnished by the manufacturers. In the second experiment we procured the separate ingredients, and mixed the feed ourselves. Each of the two milk experiments was made with six cows. In the first experiment the feed consisted of a constant grain and ensilage ration, together with a good quality of first-cut hay and cotton-seed feed; in the second experiment there was a constant grain and mangel ration, in addition to the hay and cotton-seed feed. The cotton-seed feed was looked upon as being similar in character to hay, and, in attempting to get at its value, from 12 to 15 pounds were substituted daily for a like quantity of hay. The first experiment lasted twenty-one days and the second twenty-eight days. In case of digestion experiments, in which six single tests were made, some of the sheep received nothing but the cotton-seed feed, and others received half hay and half of the feed. While the cotton-seed feed has not an attractive appearance, the animals in all cases ate their daily rations with no apparent objections.

The Results.

I. The total average gain of the six cows in live weight during the cotton-seed period was 95 pounds, and during the hay period 166 pounds.

II. The production of milk, milk solids and butter fat was so nearly alike in the average of both experiments as to be within the limits of experimental error.

III. The cost of producing milk and butter with the hay and with the cotton-seed ration varied but very little.

IV. A ton of cotton-seed feed contained about 964 pounds of digestible matter, and a ton of the hay about 1,007 pounds of digestible material.

V. A full description of the experiments, together with all data bearing on the results, will be found further on.

Is Cotton-seed Feed economical for Massachusetts Farmers?

There would unquestionably be no advantage for the average farmer to feed this material in place of hay, unless he could sell his hay for a sufficient advance over the cost of

the feed to warrant the change. Milkmen in the vicinity of large cities, and others who are obliged to purchase their coarse feed, might find it to their advantage to use some of this material, especially if it could be bought for less than a good quality of hay. It is possible that animals would tire of this feed sooner than of hay. The cows used by the station consumed it continuously for over a month with no seeming objections. The cotton-seed feed must be looked upon from a feeding stand-point in the light of a hay substitute, and not as a grain feed, and only 8 to 10 pounds should be fed each animal daily, in place of a like amount of hay or other coarse fodder. Southern rather than northern farmers can utilize cotton-seed feed to the best advantage.

The Experiments in Detail.

In 1889 Stone * records the fact that increasing quantities of cotton-seed hulls and various mixtures of hulls and cotton-seed meal were being fed by the farmers of the south for beef and milk production. Since 1889 a great variety of digestion and beef-producing experiments have been made by the North Carolina station,† which have been productive of a large amount of information relative to the physiological and economic value of cotton-seed feed. The Texas experiment station ‡ has made experiments with milch cows to study the economic value of this feed in a variety of fodder rations.

In 1894 Armsby § published the results of two experiments with cotton-seed feed. In the first experiment the cows, five in number, were fed as follows: Ration I. consisted daily of 7.95 pounds of wheat bran and 11.69 pounds of cotton-seed feed; while Ration II. contained 3 pounds of cotton-seed meal, 7 pounds of corn meal, 6 pounds of corn fodder and 3.27 pounds of hay. Practically, the corn meal and cotton-seed meal of the second ration were matched against the bran, and cotton-seed meal contained in the cotton-seed feed of the first ration, leaving the corn fodder

* Tennessee Experiment Station, Vol. II., No. 3, 1889.
† Bulletins 80*c*, 81, 87*d*, 93, 97, 106, 109, 118.
‡ Bulletin 33, 1894.
§ Report Pennsylvania Experiment Station, page 44, 1894.

and hay to be compared with about the same quantity of cotton hulls. The results, as would naturally be expected, were in favor of Ration II. This latter ration contained also 4 pounds more of digestible matter. In the second trial, six cows were each given daily 6 pounds of Buffalo gluten feed and 2 pounds of wheat bran. Ration I. contained in addition 10.6 pounds of cotton-seed feed, and Ration II. 4 pounds of corn meal and 9.7 pounds of clover hay. It is not possible to regard this as a fair comparison, for any one can see at a glance that 4 pounds of corn meal and 9.7 pounds of clover hay (13.7 pounds) must give better results than 10.6 pounds of cotton-seed feed. At least a fairer comparison would have been to have matched the cotton-seed feed against a like quantity of clover hay. Simply because cotton-seed feed consists of a mixture of cotton-seed hulls with cotton-seed meal, it is not at all necessary when making a comparison to put the like amount of cotton-seed meal or other grain into the opposite ration. By so doing, one simply compares cotton-seed hulls with some other fodder or fodder combination. The hulls themselves have an inferior nutritive value; experiments have demonstrated that their nutritive effect is increased by the addition of the cotton-seed meal. In order, therefore, to get at the feeding value of this material, it must be regarded as a single feed stuff, and ought to be compared with other coarse fodders of similar composition. It has been the aim of the experimenter, in the two experiments that follow, to make such a comparison.

A. Composition of Cotton-seed Feed.

The first lot of feed, supplied through the kindness of Mr. H. C. Haskell of the Southern Cotton Oil Company of Savannah, Ga., was said to have been mixed in the proportion of 1,600 pounds of hulls to 400 pounds of meal. The lot for the second experiment we prepared ourselves, in the same proportion. The two lots varied very little in moisture, but, for the sake of more exact comparison, the results are presented in dry matter.

	No. 1 (Per Cent.).	No. 2 (Per Cent.).	Theoretical Protein Content of No. 2 (Per Cent.).	Composition of Two Samples of Hay fed in the Two Experiments (Per Cent.).	
				I.	II.
Ash, . . .	3.82	3.51	–	5.94	5.78
Protein, . .	13.02	11.98	13.85	11.07	8.41
Fibre, . . .	39.67	40.69	–	32.00	33.98
Extract matter, .	39.59	40.13	–	47.92	49.15
Fat, . . .	3.90	3.69	–	3.07	2.68

Both Nos. 1 and 2 run rather below the theoretical percentage of protein. This is not surprising, from the fact that it is extremely difficult to get a strictly average sample of this feed. It is impossible to grind the hulls fine, and in spite of all one can do, more or less of the meal will fall through the hulls and not be included in the sample. It will be noted that the cotton-seed feed and the hay resemble each other in chemical composition, excepting that the cotton-seed feed contains somewhat more fibre and less extract matter.

B. Digestibility of Cotton-seed Feed.

Recognizing the valuable information secured by digestion tests, six single trials with sheep were made of the two samples of feed. The sheep were grade Southdown mature wethers. In four cases the cotton-seed feed was fed alone, and in the remaining two the daily ration consisted of one-half hay and one-half cotton-seed feed. In both cases the results agree quite closely, except in case of the fat, which showed a digestibility of 98 per cent. when the cotton-seed feed was fed in connection with hay. This high result it was thought best to exclude from the average. The cotton-seed feed appeared to agree better with the sheep when fed in connection with hay than when fed by itself. In the latter case, at the close of the period the sheep began to show signs of diges-

tion disturbances, which would certainly have become quite pronounced had the feeding been continued much longer. The digestibility of the two different samples of cotton-seed feed was practically the same. The North Carolina station has made a very extended study of the digestibility of hulls and meal fed in different proportions. The Pennsylvania station has also made three single determinations. These results, in addition to our own, are tabulated below: —

Digestion Coefficients.

	Proportions fed.	Number Single Determinations.	Dry Matter (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Extract Matter (Per Cent.).	Fat (Per Cent.).
Massachusetts station,	4-1	6	56	41	56	59	92
North Carolina station,	6-1	2	46	46	40	50	82
North Carolina station,	4-1	2	54	54	45	58	85
North Carolina station,	3-1 1½-1	9	54	64	47	54	85
Pennsylvania station,	5-1	3	43	36	31	54	84
Hay of mixed grasses with ten per cent. protein for comparison.	-	-	58	58	60	59	48

The experiments made by the North Carolina station (4–1) and by the Pennsylvania station were carried out with steers. The only difference between the results obtained by the Massachusetts station and those recorded by the North Carolina station (4–1) consists in the higher percentage of protein and the lower percentage of fibre digested by the steers in the North Carolina experiments. The coefficients for fat digestibility also show some variation, but, the fat percentage being comparatively small, the difference is not of so much account. The coefficients obtained by Armsby are lower than would be expected. The coefficients of digestibility for an extra quality of hay are not very noticeably higher — excepting the protein — than those for the cotton-seed feed.

According to the average coefficients of digestibility, a ton of the hay and a ton of the cotton-seed feed fed in the

milk experiments would contain the following amounts of digestible organic nutrients : —

One ton hay, ...	1,007.3
One ton cotton-seed feed, ...	964.4

One would therefore suppose that a ton of cotton-seed feed would have nearly the same feeding value as a like quantity of hay. There might be one exception to the above statement, in that it is possible that rather more energy would be required to digest the cotton-seed feed than the hay.

C. Milk Experiments with Cotton-seed Feed.

Experiment I.

This experiment was conducted during April and May, 1896. The animals, six in number, were evenly divided into two lots. In order to counteract the natural milk shrinkage, three of the animals in the first half of the experiment were fed the cotton-seed feed ration, while the other three were having the hay ration. In the second half this order was reversed. Each half of the experiment lasted twenty-one days, and from seven to ten days were allowed between the halves.

History of the Cows.

NAME.	Breed.	Age (Years).	Last Calf dropped.	Number of Days with Calf.	Milk Yield at Beginning of Experiment (Pounds).
Ada, . .	Grade Ayrshire,	7	Oct. 1	106	19
Red Spot, .	Grade Durham, .	6	Sept. –	90	21
Bessie, .	Grade Ayrshire,	7	Sept. 10	69	25
Beauty, .	Grade Jersey, .	5	Sept. 15	96	20
Red, . .	Grade Durham,	7	Oct. 8	141	20
Spot, . .	Grade Durham, .	7	Oct. 8	141	20

Five of the above cows had been in two previous experiments since October, 1895.

Dates of the Experiment.

	Cotton-seed Ration.	Hay Ration.
April 8 through April 28, . . .	Cows 3, 4, 5	Cows 1, 2, 6
May 11 through May 31, . . .	Cows 1, 2, 6	Cows 3, 4, 5

Rations consumed Daily (Pounds).

Period.	Name.	Hay.	Cotton-seed Feed.	Wheat Bran.	Peoria Gluten Feed.	Linseed Meal.	Millet and Soy Bean Ensilage.
Cotton-seed feed.	Ada, . .	–	10	2	3	1	15,
	Red Spot, .	–	13	3	2	2	20
	Bessie, . .	–	15	3	2	2	20
	Beauty, . .	–	15	3	2	2	20
	Red, . . .	–	15	3	2	2	20
	Spot, . .	–	13	3	2	2	20
Hay.	Ada, . .	10	–	2	3	1	15
	Red Spot, .	13	–	3	2	2	20
	Bessie, . .	15	–	3	2	2	20
	Beauty, . .	15	–	3	2	2	20
	Red, . . .	14.2	–	3	2	2	20
	Spot, . .	13	–	3	2	2	20
Average cotton-seed feed.		–	13.5	2.83	2.17	1.83	19.17
Average hay, . .		13.47	–	2.83	2.17	1.83	19.17

Although but three of the six cows received the same ration at the same time, each animal received during the experiment the two different rations for exactly the same length of time. It will be observed that the only difference between the rations consists in the substitution of the cotton-

seed feed for the hay, and *vice versa*. The entire rations were eaten clean, excepting a small amount of hay refused by Red, which was preserved, analyzed and deducted from the total fed. The feeds were weighed out daily and given in two portions. Water was before the animals constantly. The cows were carded daily, and allowed the run of a yard in pleasant weather.

Digestible Nutrients in Daily Rations (Pounds).

Period.	Name.	Total Dry Matter.	Digestible.				Nutritive Ratio.
			Protein.	Carbohydrates.	Fat.	Total.	
Cotton-seed feed	Ada,	17.36	1.77	8.30	.67	10.74	1 : 5.63
	Red Spot,	21.88	2.23	10.10	.82	13.15	1 : 5.45
	Bessie,	23.42	2.31	10.82	.86	13.99	1 : 5.61
	Beauty,	23.42	2.31	10.82	.86	13.99	1 : 5.61
	Red,	23.42	2.31	10.82	.86	13.99	1 : 5.61
	Spot,	21.88	2.23	10.10	.82	13.15	1 : 5.45
Hay	Ada,	17.30	1.92	8.74	.50	11.16	1 : 5.20
	Red Spot,	21.81	2.42	10.70	.59	13.71	1 : 5.03
	Bessie,	23.90	2.57	11.05	.64	14.26	1 : 4.92
	Beauty,	23.90	2.57	11.05	.64	14.26	1 : 4.92
	Red,	23.19	2.53	10.72	.63	13.88	1 : 4.86
	Spot,	21.81	2.42	10.70	.59	13.71	1 : 5.03
Average cotton-seed feed.		21.89	2.19	10.16	.82	13.17	1 : 5.56
Average hay,		21.99	2.41	10.49	.60	13.50	1 : 4.99

The coefficients of digestibility for the cotton-seed feed and for the hay used in calculating the above digestible nutrients were those obtained in our experiments with sheep. Average coefficients were used for the grain feeds. The above results show but little variation in the digestible amounts of the several groups contained in the two rations.

Weight of Animals at Beginning and End of Experiment (Pounds).

		Ada.	Red Spot.	Bessie.	Beauty.	Red.	Spot.	Total Herd Gain.
Cotton-seed period,	Beginning,	771	891	795	937	1010	967	10
	End,	771	888	792	928	1025	977	
Hay period,	Beginning,	775	892	861	1000	1070	965	40
	End,	775	902	855	1012	1082	977	

Two weights were taken of each animal at the beginning and two at the end of the experiment. No marked variations were noted due to the influence of either ration.

Yield of Milk and Butter.

PERIOD.	Cows.	Total Yield of Milk (Pounds).	Daily Yield of Milk (Pounds).	Daily Yield of Milk (Quarts).	Total Milk Solids (Pounds).	Total Butter Fat (Pounds).	Total Butter (Pounds).	Daily Yield of Butter (Pounds).
Cotton-seed Feed.	Ada,	395.48	18.83	8.76	54.60	19.53	22.78	1.08
	Red Spot,	439.12	20.91	9.72	62.58	22.89	26.70	1.27
	Bessie,	542.11	25.71	11.96	73.50	26.67	31.11	1.48
	Beauty,	444.00	21.14	9.83	66.99	24.99	29.15	1.39
	Red,	416.62	19.82	9.22	58.38	21.00	24.50	1.17
	Spot,	337.25	16.06	7.47	50.82	18.27	21.31	1.01
Hay.	Ada,	402.71	19.18	8.92	54.60	18.60	21.70	1.03
	Red Spot,	458.75	21.84	10.16	64.05	21.29	24.84	1.11
	Bessie,	526.86	25.09	11.67	70.35	23.81	27.78	1.32
	Beauty,	399.89	19.04	8.86	58.17	20.35	23.74	1.13
	Red,	275.50	13.12	6.43	38.22	12.84	14.98	.71
	Spot,	419.50	19.98	9.29	61.53	22.11	25.80	1.23
Total cotton-seed feed,		2,574.58	122.47	56.96	366.87	133.33	155.55	7.40
Total hay,		2,483.21	118.25	55.33	346.92	119.00	138.84	6.60
Percentage increase cotton-seed feed over hay.		3.6+	-	-	5.44+	10.76+	-	-

The cotton-seed feed ration gave a slightly larger amount of milk than the hay ration. A 5.4 percentage increase in the amount of total solids is also noted, while fully ten per

cent. more butter fat was produced by the cotton-seed ration. This latter result could hardly have been expected. Should cotton-seed feed exert a favorable influence in increasing the relative amount of butter fat in the milk, other experiments would show similar results, which we shall presently show has not been the case. A part of the decrease in the amount of milk, solids and fat produced by the hay ration can be accounted for in the sudden shrinkage of Cow V. (Red) in the second (hay) period. This cow was a grade Durham, and at the beginning of her second period was about 105 days from calving time. She began then to dry off rapidly, showing a shrinkage of 34 per cent. in yield of milk from that produced in the previous period, while other animals shrank only from 5, to in one case 20 per cent. Had Red shrank only 20 per cent., the total decrease in milk yield in the hay period would have been but a trifle over 1 per cent. The results of this experiment make rather more of a favorable showing for the cotton-seed feed than one would naturally expect, judging from its composition and digestibility. Before, therefore, drawing positive conclusions, the reader is referred to the results of a second experiment, described further on.

Dry and Digestible Matter required to produce Milk and Butter (Per Cent.).

Dry Matter required to Produce —	Cotton-seed Period.	Hay Period.	Digestible Matter required to produce —	Cotton-seed Period.	Hay Period.
100 pounds milk, . .	107.10	111.56	100 ponnds milk, .	64.40	68.49
1 ponnd milk solids, .	7.52	7.98	1 ponnd milk solids, .	4.52	4.90
1 pound milk fat, . .	20.69	23.27	1 pound milk fat, .	12.44	14.28
1 pound butter, . .	17.75	19.99	1 ponnd bntter, . .	10.68	12.27

Market Cost of Feed Stuffs.

Wheat bran, ...	$15 00	per ton.
Peoria gluten feed, ...	15 00	"
Linseed meal, ...	20 00	"
Millet and soya bean ensilage, . .	3 50	"
Hay, ...	15 00	"
Cotton-seed feed, ...	15 00	"

With the above figures as a basis, we obtain the following figures for the cost of feed required to produce milk and butter: —

	COWS.	Daily Feed (Cents).	100 Pounds Milk (Cents).	Quart of Milk (Cents).	Pound Butter Fat (Cents).	Pound Butter (Cents).
Cotton-seed period.	Ada,	14.87	79.00	1.69	15.99	13.77
	Red Spot,	19.00	90.90	1.95	17.43	15.00
	Bessie,	20.50	79.70	1.71	16.14	13.85
	Beauty,	20.50	97.00	2.08	17.23	14.03
	Red,	20.50	103.40	2.22	20.50	17.52
	Spot,	19.00	118.20	2.54	21.84	18.81
Hay period.	Ada,	14.87	77.50	1.67	16.71	14.43
	Red Spot,	19.00	87.00	1.87	18.81	16.10
	Bessie,	20.50	81.70	1.76	18.14	15.53
	Beauty,	20.50	107.60	2.31	21.13	18.14
	Red,	19.90	151.70	3.09	32.62	28.03
	Spot,	19.00	95.00	2.05	18.09	15.45
Average cotton-seed feed period.		19.06	94.70	2.03	18.19	15.49
Average hay period,		18.96	100.10	2.12	20.92	17.94

The two rations costing the same, the cost of producing milk and butter was rather favorable to the cotton-seed feed ration.

Experiment II. (1896).

In view of the results obtained in the first experiment, it was thought advisable to conduct a second under practically the same conditions. The six cows were all approximately fresh in milk. The experiment was carried out in exactly the same way as the preceding one.

History of Cows.

NAME.	Breed.	Age (Years).	Last Calf Dropped.
Mary, . . .	Grade Jersey, . .	9	July 1.
Jennie, . . .	Grade Guernsey, .	6	September.
Nora, . . .	Grade Jersey, . .	10	August 23.
Beauty, . . .	Grade Jersey, . .	6	September 15.
Red, ...	Grade Durham, . .	8	August 20.
Spot, ...	Grade Durham, . .	8	August 17.

The cows were farrow at the beginning of the experiment, and all were served during the progress of the trial.

Dates of the Experiment.

	Cotton-seed Period.	Hay Period.
October 6 through November 3, . .	Cows 1, 2, 5.	Cows 3, 4, 6.
November 17 through December 15, .	Cows 3, 4, 6.	Cows 1, 2, 5.

Rations eaten Per Day (Pounds).

	NAME.	Hay.	Cotton-seed Feed.	Mangolds.	Wheat Bran.	Chicago Gluten Meal.
Cotton-seed period.	Mary, . . .	2	15	15	5	3
	Jennie, . . .	3	12	15	5	3
	Nora, . . .	–	15	15	5	3
	Beauty, . . .	5	15	15	5	3
	Red, . . .	3	15	15	5	3
	Spot, . . .	3	14.46	15	5	3

Rations eaten Per Day (Pounds) — Concluded.

	NAME.	Hay.	Cotton-seed Feed.	Mangolds.	Wheat Bran.	Chicago Gluten Meal.
Hay period.	Mary,	17	–	15	5	3
	Jennie,	15	–	15	5	3
	Nora,	15	–	15	5	3
	Beauty,	20	–	15	5	3
	Red,	18	–	15	5	3
	Spot,	18	–	15	5	3
Average cotton-seed feed period.		2.68	14.41	15	5	3
Average hay period,		17.17	–	15	5	3

It was not considered advisable to feed more than from 12 to 15 pounds of the cotton-seed feed daily, and the additional quantity of coarse fodder was secured by adding from 2 to 5 pounds of hay, to suit the appetites of the various animals. We have, then, 12 to 15 pounds of cotton-seed feed, compared with a like amount of hay. The cotton-seed feed was mixed daily in the proportion of 4 pounds of hulls to 1 pound of meal. The hay was a mixture of grasses, with Timothy predominating. Some clover was scattered through the mixture.

Digestible Matter in Rations (Per Cent.).

	NAME.	Total Dry Matter.	DIGESTIBLE.				Nutritive Ratio.
			Protein.	Carbohydrates.	Fat.	Total.	
Cotton-seed period	Mary,	23.20	2.45	10.58	.83	13.86	1:5.08
	Jennie,	21.44	2.37	9.78	.76	12.91	1:4.85
	Nora,	21.44	2.37	9.76	.81	12.94	1:4.85
	Beauty,	25.83	2.57	11.82	.87	15.26	1:5.36
	Red,	24.07	2.49	10.99	.85	14.33	1:5.60
	Spot,	23.61	2.47	10.77	.83	14.07	1:5.08

Digestible Matter in Rations (Per Cent.) — Concluded.

	NAME.	Total Dry Matter.	DIGESTIBLE.				Nutritive Ratio.
			Protein.	Carbohydrates.	Fat.	Total.	
Hay period.	Mary, . . .	23.17	2.41	10.67	.56	13.64	1 : 4.95
	Jennie, . . .	21.42	2.33	9.85	.54	12.72	1 : 4.77
	Nora, . . .	21.42	2.33	9.85	.54	12.72	1 : 4.77
	Beauty, . . .	25.78	2.53	11.91	.60	15.04	1 : 4.30
	Red, . . .	24.08	2.45	11.08	.58	14.11	1 : 5.00
	Spot, . . .	24.08	2.45	11.08	.58	14.11	1 : 5.00
Average cotton-seed feed period.		23.26	2.45	10.62	.82	13.64	1 : 5.14
Average hay period, .		23.32	2.42	10.74	.57	13.72	1 : 5.00

The amounts and proportions of digestible matter in each of the two rations are identical. In calculating the above rations, average digestion coefficients were taken for the grains, the coefficients obtained at this station for the cotton-seed feed, and in case of the hay, the coefficients obtained by us for hay of similar appearance and composition. It must be remembered that the above digestible material in the two rations is only estimated. It is therefore quite possible that, had actual digestion experiments been made with the cows, these figures may have been somewhat modified.

Weight of Animals at Beginning and End of Experiment (Pounds).

		Mary.	Jennie.	Nora.	Beauty.	Red.	Spot.	Total Gain.
Cotton-seed period, .	Beginning, . .	768	818	745	943	1,006	1,007	-
	End, . . .	767	840	767	954	1,042	1,002	85
Hay period, . . .	Beginning, . .	829	897	757	946	1,096	954	-
	End, . . .	825	888	780	973	1,115	1,024	126

The cows were weighed at the same time for three consecutive days at the beginning and end of the experiment.

Four of the six cows were rather thin in flesh at the beginning of the test, and made gains on both rations. The hay period showed a herd increase of 41 pounds over the cotton-seed period.

Milk and Butter Yields (Pounds).

PERIOD.	Cows.	Total Milk.	Daily Milk.	Daily Quarts.	Total Milk Solids.	Total Fat.	Total Butter.	Daily Butter.
Cotton-seed period.	Mary,	596.88	21.32	9.92	83.38	28.29	33.00	1.18
	Jennie,	609.97	21.78	10.13	88.81	30.50	35.59	1.27
	Nora,	519.12	18.54	8.62	69.81	23.62	27.56	.98
	Beauty,	587.68	20.99	9.76	84.75	30.97	36.13	1.29
	Red,	549.94	19.64	9.13	67.63	21.28	24.82	.88
	Spot,	428.77	15.31	7.12	62.23	22.42	26.16	.93
Hay period.	Mary,	575.64	20.55	9.57	79.83	27.34	31.90	1.14
	Jennie,	527.12	18.82	8.75	80.49	30.46	35.54	1.27
	Nora,	613.34	21.89	10.17	80.77	24.78	28.91	1.03
	Beauty,	685.67	24.47	11.38	97.85	33.60	39.20	1.40
	Red,	557.00	19.89	9.25	69.62	22.72	26.51	.95
	Spot,	491.17	17.56	8.17	70.83	23.23	27.10	.97
Average cotton-seed feed ration.		548.73	19.59	9.10	76.10	26.18	30.54	1.09
Average hay ration,		574.99	20.53	9.55	79.90	27.02	31.53	1.13
Percentage increase hay over cotton-seed period.		4.6+	-	-	4.8+	3.1+	-	-

In this experiment, the results are the reverse of those obtained in the first test, the hay period yielding several per cent. more milk, milk solids and fat. Our observations of the animals from day to day during the trial indicated that the cotton-seed feed ration was falling slightly behind the hay ration. The animals, being in the early part of the lactation period, would naturally be more sensitive to the effect of food than in the latter portion of the period of lactation.

Dry and Digestible Matter required to produce Milk and Butter (Per Cent.).

Dry Matter required to produce —	Cotton-seed Period.	Hay Period.	Digestible Matter required to produce —	Cotton-seed Period.	Hay Period.
100 pounds milk, . .	118.70	113.60	100 pounds milk, .	70.90	66.90
1 pound milk solids, .	8.56	8.18	1 pound milk solids, .	5.11	4.81
1 pound milk fat, . .	24.88	24.17	1 pound milk fat, .	14.86	14.22
1 pound butter, . .	21.38	20.70	1 pound butter, . .	12.77	12.18

Market Cost of Feed Stuffs.

Wheat bran, ...	$14 00 per ton.
Chicago gluten meal, ...	18 00 "
Mangolds, ...	3 00 "
Hay, ...	15 00 "
Cotton-seed feed, ...	15 00 "

Cost of Feed to produce Milk and Butter. Average for Six Cows (Cents).

	Daily Feed.	100 Pounds Milk.	Quart Milk.	Pound Butter Fat.	Pound Butter.
Cotton-seed period, ...	21.32	110.6	2.38	23.40	20.10
Hay period, ...	21.32	104.9	2.26	22.69	19.33
Increased percentage cost of cotton-seed over hay period.	-	5.2+	-	-	3.2+

The cotton-seed rations slightly increased the cost of the milk and butter.

D. Average Results from Two Experiments.

It is thought desirable to bring together the results of both experiments, believing that they will give a fair representation of the relative values of like quantities of cotton-seed feed and a good quality of hay.

1. Total Live Weight gained by the Six Cows in Both Experiments (Pounds).

Cotton-seed feed periods, ...	95
Hay periods, ...	166

2. *Average Dry and Digestible Matter Consumed Daily (Pounds).*

	Total Dry Matter.	Digestible.				Nutritive Ratio.
		Protein.	Fat.	Carbohydrates.	Total.	
Cotton-seed period, .	22.57	2.32	.82	10.39	13.40	1 : 5.35
Hay period, . . .	22.65	2.41	.59	10.61	13.61	1 : 5.00

These figures show very slight variations.

3. *Total Milk and Butter Yields (Pounds).*

	Milk.	Milk Solids.	Milk Fat.	Butter.
Cotton-seed period, ...	5867	823.5	290.4	338.8
Hay period, ...	5933	826.3	281.1	328.0
Percentage increase hay over cotton-seed,	1.1+	.34+	3.2—	3.2—

These variations can be regarded as within the limits of experimental error.

4. *Average Feed Cost of Milk and Butter (Cents).*

	Daily Cost of Feed.	100 Pounds Milk.	Quart Milk.	Pound Butter Fat.	Pound Butter.
Cotton seed period, ...	20.19	102.6	2.20	20.79	17.79
Hay period, ...	20.14	102.5	2.19	21.80	18.63
Percentage increased cost of hay over cotton-seed.	±	±	±	4.63+	4.5+

The 4.6 percentage increased cost of butter in the hay period is due to the rather unexpected results in the first experiment.

5. *Dry and Digestible Matter required to produce Milk and Butter.*

I. Dry Matter (Pounds).

	100 Pounds Milk.	Pound Milk Solids.	Pound Butter Fat.	Pound Butter.
Cotton-seed period, ...	112.9	8.04	22.79	19.56
Hay period, ...	112.6	8.08	23.72	20.37

II. Digestible Matter (Pounds).

	100 Pounds Milk.	Pound Milk Solids.	Pound Butter Fat.	Pound Butter.
Cotton-seed period, ...	67.65	4.81	13.65	11.72
Hay period, ...	67.69	4.85	14.25	12.22

General Conclusions.

Cotton-seed feed, from its appearance, is certainly not an attractive looking article for consumption. The cotton-seed hulls, comprising the bulk of the feed, consists of the dark seed coats, together with an entangling mass of fibre. They are difficult to masticate, and quite indigestible. The cotton-seed meal with which the hulls are mixed imparts its flavor to the material, and actually increases the digestibility of the hulls. In our experiments we have had no trouble in inducing animals to eat 12 to 15 pounds daily within three or four days. The two experiments have shown cotton-seed feed to give as large milk and butter yields, at as low a cost, as a good quality of hay. The writer is of the opinion, however, that this feed requires more energy for its digestion than hay, and, when fed for any length of time, would have a tendency to induce digestive disturbances. A mixture of hulls and meal could probably be turned to better account for fattening steers than as a continuous feed for dairy cows. Massachusetts farmers could derive no benefit from feeding this material in place of hay. For those who are obliged to purchase all of their coarse feeds, it might be desirable to use one-half of this material in place of hay, provided it could be purchased for somewhat less money. Cotton-seed feed should be consumed where it is produced. For the farmers of the south it is undoubtedly a cheap source of coarse feed, and, when fed in moderate quantities, will unquestionably return good results.

Analytical Data.

Dry Matter Determinations (Per Cent.).

Experiment I.

	Hay.	Millet and Soy Bean Ensilage.	Cotton seed-Feed.	Wheat Bran.	Linseed Meal.	Peoria Gluten Feed.
April 8 through April 28, .	90.33	18.79	89.00	87.89	90.58	93.04
May 11 through May 31, .	89.84	20.58	88.10	87.86	90.48	93.23

Experiment II.

	Hay.	Mangolds.	Cotton-seed Feed.	Wheat Bran.	Chicago Gluten Meal.
Hay * and cotton-seed periods, . .	87.60	8.09	87.8	87.2	90.6

* The dry matter determinations varied so little in the two halves of this experiment that the average in each case was taken.

Composition of Feeds (Per Cent.).

Experiment I.

	Hay.	Millet and Soy Bean Ensilage.	Cotton-seed Feed.	Wheat Bran.	Linseed Meal.	Peoria Gluten Feed.
Ash, ...	5.94	12.77	3.82	6.42	4.94	1.07
Fibre, ...	32.00	34.02	39.67	11.37	7.26	7.13
Fat, ...	3.07	2.59	3.90	5.73	7.05	7.59
Protein, ...	11.07	9.40	13.02	18.68	41.99	23.83
Extract matter, ...	47.92	41.22	39.59	57.80	38.76	60.38

Experiment II.

	Hay.	Mangolds.	Cotton-seed Feed.	Wheat Bran.	Chicago Gluten Meal.
Ash, ...	5.78	15.49	3.51	7.11	1.52
Fibre, ...	33.98	10.67	40.69	12.08	3.21
Fat, ...	2.68	.73	3.69	5.69	7.38
Protein, ...	8.41	14.35	11.98	18.12	40.38
Extract matter, ...	49.15	58.76	40.13	57.00	47.51

Coefficients of Digestibility.

Experiment I.

	Hay.	Ensilage.	Cotton-seed Feed.	Wheat Bran.	Linseed Meal.	Peoria Glu ten Feed.	Chicago Glu ten Meal.	Mangolds.
Fibre,	66	69	59	22	57	78	-	-
Fat,	53	72	89	71	89	79	-	-
Protein,	62	57	39	78	89	83	-	-
Extract Matter,	64	59	58	68	78	90	-	-

Experiment II.

Fibre,	58	-	55	22	-	-	-	43
Fat,	50	-	93	68	-	-	93	-
Protein,	54	-	42	79	-	-	89	75
Extract Matter,	56	-	59	69	-	-	93	91

Composition of Milk (Per Cent.).

Experiment I.

	Ada.		Red Spot.		Bessie.	
	Solids.	Fat.	Solids.	Fat.	Solids.	Fat.
Cotton-seed period,	13.84	4.93	14.01	4.84	13.63	4.93
	13.82	5.00	14.48	5.59	-	-
Average,	13.83	4.96	14.24	5.21	13.63	4.93
Hay period,	13.57	4.62	13.95	4.64	13.26	4.53
	-	-	-	-	13.47	4.52
Average,	13.57	4.62	13.95	4.64	13.36	4.52

Experiment I. — Concluded.

	Beauty.		Red.		Spot.	
	Solids.	Fat.	Solids.	Fat.	Solids.	Fat.
Cotton-seed period, . .	15.08	5.62	14.03	5.05	14.88	5.33
	-	-	-	-	15.28	5.48
Average, . . .	15.08	5.62	14.03	5.05	15.08	5.40
Hay period, . . .	14.54	5.13	13.91	4.72	14.77	5.27
	14.61	5.05	13.87	4.60	-	-
Average, . . .	14.57	5.09	13.89	4.66	14.77	5.27

Experiment II.

	Mary.		Jennie.		Nora.	
	Solids.	Fat.	Solids.	Fat.	Solids.	Fat.
Cotton-seed period, . .	13.96	4.64	14.36	4.73	13.39	4.48
	13.81	4.80	14.58	5.33	13.44	4.58
	14.20	4.93	14.58	4.92	13.52	4.63
	13.91	4.74	14.73	5.00	13.45	4.50
Average, . . .	13.97	4.74	14.56	5.00	13.45	4.55
Hay period, . . .	13.76	4.73	14.79	5.45	13.00	3.81
	13.86	4.75	15.39	5.88	12.93	4.10
	14.01	4.85	15.55	6.00	13.46	4.17
	13.85	4.68	15.37	5.78	13.28	4.07
Average, . . .	13.87	4.75	15.27	5.78	13.17	4.04

Experiment II. — Concluded.

	Beauty.		Red.		Spot.	
	Solids.	Fat.	Solids.	Fat.	Solids.	Fat.
Cotton-seed period,	14.62	5.35	12.48	3.89	14.57	5.08
	13.95	4.85	11.88	3.93	14.77	5.05
	14.66	5.48	12.60	4.02	14.92	5.15
	14.46	5.40	12.23	3.63	13.90	5.63
Average,	14.42	5.27	12.30	3.87	14.54	5.23
Hay period,	-	-	12.26	4.00	14.01	4.34
	14.12	4.93	12.41	4.05	14.14	4.75
	14.49	4.97	12.74	4.20	14.59	4.94
	14.19	4.80	12.53	4.08	14.94	4.91
Average,	14.27	4.90	12.49	4.08	14.42	4.73

Average Results of Six Cows.

	Experiment I.		Experiment II.	
	Solids.	Fat.	Solids.	Fat.
Cotton-seed period,	14.31	5.18	13.87	4.78
Hay period,	14.02	4.80	13.91	4.71

Each distinct analysis represents a composite sample from 8 different milkings. In Experiment I., samples were taken for four days of the last two weeks only. In Experiment II., each analysis represents the comparison of the milk for each of the four weeks.

REPORT OF THE ENTOMOLOGIST.

CHARLES H. FERNALD.

Two bulletins have been issued from this department during the year, — one on the habits, food and economic value of the American toad (*Bufo lentiginosus americanus*), and one on the brown-tail moth (*Euproctis chrysorrhœa*). I have been able in the intervals of other duties to prepare a monograph of the plume-moths (*Pterophoridæ*) of North America, which is published with illustrations in the thirty-fifth annual report of the college. A large amount of time has also been devoted to the work on the gypsy moth in the eastern part of the State.

San José Scale.

The San José scale (*Aspidiotus perniciosus*) has appeared in many places in Massachusetts, having been received on nursery stock from nurseries both in this and in other States. In the early part of the season my assistants visited, as far as possible, all the nurseries in the State, and carefully examined them for this scale. Most of them appeared to be entirely free from this insect, but a few were more or less infested. The owners of these infested nurseries have taken the most active measures to destroy this pest, under the supervision of one of my assistants. Many of the nurserymen do not raise a sufficient amount of stock to supply all of their orders, and often purchase from outside sources. This stock is often received and sent out without examination, and in this way it is possible for the San José scale to be distributed by those whose nurseries are not infested. A bulletin on the San José scale will be published as soon as other duties will permit, in which will be given a more complete account of the condition of the nurseries visited, together with the measures taken to eradicate the pest.

The scale insects have been and are still being introduced into this country from other parts of the world, and in this way we are liable at any time to find new or unknown species on our fruit or ornamental trees and shrubs and in our greenhouses. It therefore seems wise to learn as much as possible about these insects, in order that we may know what to do with those already here, and any that may hereafter be brought into this country. To this end, more than six hundred circular letters were sent out to all entomologists whose names and addresses could be obtained, asking for specimens of two genera of the scale insects, and already a large amount of material has been received. Prof. R. S. Lull has undertaken to work up and prepare a monograph of the genus *Pulvinaria*, and Mr. R. A. Cooley a monograph of the genus *Chionaspis*. Very commendable progress has already been made by these two gentlemen.

Army Worm.

During the summer of 1896 the army worm (*Leucania unipuncta*) was very abundant in Amherst and in many other parts of the State, often in destructive numbers, and in the correspondence with this department information concerning this insect was asked for more than of all others combined. During the summer of 1897, however, the army worm seems to have been present in so few numbers as to have done no harm, and it was not referred to in a single letter received by me. It is a well-known fact that this insect has never in the past appeared in destructive numbers two years in succession in the same place, and the past season seems to have been no exception. The caterpillars were reported in many cases to have been more or less infested with the eggs of a parasitic fly. These eggs no doubt hatched and the young maggots made their way into the caterpillars and destroyed them, thus reducing the army worm to insignificant numbers, so that the few remaining have been entirely overlooked.

Plant Lice.

While the army worm has been very scarce during the past season, the aphids or plant lice have been very abundant on trees and shrubs, and many letters have been received, asking

how to destroy them. The best method, so far as known, is to spray the trees with kerosene emulsion; but in spraying it is very difficult to reach every insect, and, as they multiply very rapidly, they soon become as abundant as ever, and it becomes necessary to spray the trees or shrubs repeatedly after short intervals.

Tobacco Cutworm.

Early in the season cutworms were said to be destroying the young tobacco plants in the tobacco fields of the Connecticut valley, and specimens that were brought in and bred to maturity developed into moths which proved to be *Carneades messoria*. The caterpillars of this species partake of a rather varied diet, consisting not only of tobacco, but also of cabbage, corn, potatoes, spinach, onions, lettuce and fruit trees. The usual method taken by our tobacco growers, so far as I can learn, is to reset tobacco plants where they have been cut off by the worms, and at the same time dig out and destroy the worm that has done the mischief.

Canker Worms.

Four years ago canker worms began to increase so rapidly in this town that public attention was called to them, and a general account of the species occurring in Massachusetts was given with illustrations in Bulletin No. 20, published in January, 1893. In that bulletin the usual remedies were given. These consisted of tacking bands of heavy paper around the trunks of the trees and painting these bands with prepared printers' ink, repainting with the ink as often as it became dry or hardened enough to permit the females to cross the band. The method of protecting the trees with oil troughs of zinc or tin around the trunks was also mentioned. It was finally stated that probably the most effectual method was to spray the trees with Paris green in water as soon as the eggs hatched in the spring. A further account of canker worms was given in Bulletin No. 28, published in April, 1895.

A careful study of the different methods used to destroy these insects, which are so prevalent in many parts of this Commonwealth, has been made on thirteen apple trees on my own premises in Amherst. Three years ago these trees were

carefully banded with heavy paper and painted with Morrill's tree ink early in the spring, when the first females began to ascend the trees, and the painting was repeated as often as necessary. It was found that the ink would often harden on the trees even during the night following the application, and remain hard on the shady side long enough in the morning for some of the females to ascend the tree on that side, so that this method did not prove to be a perfect protection. The cost of the materials and of their application averaged about fifty cents to each tree.

The oil troughs are also quite expensive, and often leak so that the rain displaces the oil and then evaporates, allowing the females to ascend the trees; or spiders spin their webs across beneath the overhanging protection, forming a bridge on which the moths may easily pass, so that this device does not form a perfect protection.

Two years ago these trees were sprayed with Paris green in water, in the proportion of one pound to one hundred and fifty gallons, at a cost of five cents a tree, allowing fifteen cents an hour for labor. There was a strong wind blowing, and more time was required to do the work than would otherwise have been the case. Last year the same trees were sprayed with Paris green, in the same proportion as before. At this time it was nearly calm, and the cost of spraying was three cents a tree. The contrast between these trees and those on adjacent lots were very marked, for the sprayed trees retained their foliage and yielded a full crop, while the unsprayed trees were stripped of leaves, and bore no fruit. These trees were sprayed but once, and this method appears to have been more effectual and far cheaper than the others. In case of rain it might be necessary to repeat the spraying, but even then it would be the cheaper method.

REPORT OF THE CHEMIST.

DEPARTMENT OF FERTILIZERS AND FERTILIZER MATERIALS.

CHARLES A. GOESSMANN.
Assistants: HENRI D. HASKINS, CHARLES I. GOESSMANN, GEORGE D. LEAVENS.

I. Report on Official Inspection of Commercial Fertilizers.
II. Report on General Work in the Chemical Laboratory.
III. Observations with Special Fertilizers on Tobacco raised in Massachusetts.

I. REPORT ON OFFICIAL INSPECTION OF COMMERCIAL FERTILIZERS AND AGRICULTURAL CHEMICALS IN 1897.

CHARLES A. GOESSMANN.

Sixty-six manufacturers and dealers in commercial fertilizers and agricultural chemicals have secured, during the past year, licenses for the sale of their goods in the State. Thirty-six of these parties have offices for the general distribution of their goods in Massachusetts; the remainder reside in other States, — ten in New York, six in Connecticut, three in Rhode Island, three in Vermont, two in Pennsylvania, one in Maryland, one in Illinois, one in Ohio and three in Canada.

The number of distinct brands licensed, including agricultural chemicals, amounted to two hundred and ninety.

The collecting and sampling of the material for official analyses were in charge of Mr. R. H. Smith, a graduate of

the Massachusetts Agricultural College in the class of 1892, who since his graduation has been an efficient assistant in the chemical laboratory of the experiment station for the examination of commercial fertilizers.

Four hundred and fifteen samples of fertilizer have thus far been collected during the present year; of these, three hundred and one samples, representing two hundred and twenty-three distinct brands, were analyzed by the close of the month of November, and the results published in July and November bulletins, Nos. 48 and 49, of the Hatch Experiment Station of the Massachusetts Agricultural College. The remaining samples, in common with others coming under our observation before the expiration of the licenses, will be analyzed in due time, and the results published in conformity with our laws for the regulation of the trade in commercial fertilizers.

The results of the inspection during the past season are, on the whole, quite satisfactory, and if anything are an improvement on the results of the preceding year. The beneficial results of improved machinery and of improved skill in the management of the manufacture of fertilizers show themselves in a marked degree when compared with the general character of commercial fertilizers in earlier periods of the business.

To render the actual conditions of the trade in commercial fertilizers during the past season more prominent, a summary of our results is here inserted. In reading the subsequent statement, it has to be remembered that only the lowest stated guarantee is legally binding in all sales: —

(*a*) Where three essential elements of plant food were guaranteed: —

Number with three elements equal to or above the highest guarantee, ... 3
Number with two elements above the highest guarantee, . . . 2
Number with one element above the highest guarantee, . . . 60
Number with three elements between the lowest and highest guarantee, ... 69
Number with two elements between the lowest and highest guarantees, ... 63
Number with one element between the lowest and highest guarantees, ... 16

Number with two elements below the lowest guarantee, . . . 6
Number with one element below the lowest guarantee, . . . 29

(*b*) Where two essential elements of plant feed were guaranteed: —

Number with two elements above the highest guarantee, . . 3
Number with one element above the highest guarantee, . . . 10
Number with two elements between the lowest and highest guarantees, ... 13
Number with one element between the lowest and highest guarantees, ... 12
Number with one element below the lowest guarantee, . . . 6
Number with two elements below the lowest guarantee, . . . 3

(*c*) Where one essential element of plant food was guaranteed: —

Number above the highest guarantee, ... 10
Number between the lowest and highest guarantees, . . . 23
Number below the lowest guarantee, ... 1

The modes of analyses adopted in this work were in all essential points those recommended by the Association of Official Chemists.

Attention has been called, in previous reports, to the fact that the introduction of a more liberal amount of potash into the make-up of a large class of so-called complete manures has become from year to year more general. This change has been slow but decided, and in a large degree may be ascribed to the daily increasing evidence, resulting from actual observations in field and garden, that the farm lands of Massachusetts are frequently especially deficient in potash compounds, and consequently need in many instances a more liberal supply of available potash from outside sources to give satisfactory returns. Whenever garden vegetables, fruits and forage crops constitute the principal products of the land, this recent change in the mode of manuring deserves a particularly careful trial; for the crops raised consume exceptionally large quantities of potash, as compared with grain crops. In view of these facts, it will be conceded that a system of manuring farm and garden which tends to meet the more satisfactory recognized conditions of large areas of land, as well as the special wants of important growing branches of agricultural industries, is a movement in the right direction.

In repeating these statements, it is not assumed that it will

remain economical to continue the practice after a repeated application of a liberal amount of potash, without some special reason.

To restore to the soil those essential manurial constituents which the crops carry off is a safe rule to follow in the effort to secure the maintenance of the fertility of the soil; yet to obtain this result in the most economical way will always remain the ultimate aim of farming as a business enterprise.

A judicious management of the trade in commercial fertilizers implies a due recognition of results well established by experiment, regarding the requirements of a remunerative production of farm and garden crops; yet, as the manufacturer at best can only prepare the composition of his special fertilizers on general lines, not knowing the particular condition and character of the soil which ultimately receives them, it becomes of the utmost importance on the part of the farmer to make himself acquainted with his special wants of manurial substances, and to thus qualify himself for a more judicious selection from the various fertilizers offered for purchase.

The present condition of the trade in commercial fertilizers offers exceptional advantages to provide efficient manures for the raising of farm and garden crops of every description congenial to soil and climate. The various essential articles of plant food, as potash, phosphoric acid and nitrogen compounds, are freely offered for sale in forms suitable to render, by their addition, the different kinds of manurial refuse matter of the farm in a higher degree fit to meet the special wants of the crops to be raised.

As the physical conditions and chemical resources of soils on available plant food frequently differ widely even on the same farm, no definite rule can be given for manuring farm lands, beyond the advice to return to the soil in available form those plant constituents which the crops raised during the preceding years have abstracted in exceptionally large proportion, and which will be especially called for by the crops to be raised.

An intelligent selection of fertilizers from among the various brands offered for sale requires, in the main, two kinds

of knowledge; namely, that the brand of fertilizer in question actually contains the guaranteed quantities and qualities of essential articles of plant food at a reasonable cost, and that it contains them in such form and proportions as will best meet under existing circumstances the special wants of soil and crop.

In some cases it may be only phosphoric acid or nitrogen or potash; in others, two of them; and in others again, all three. A remunerative use of commercial fertilizers can only be secured by attending carefully to these considerations.

To assist farmers in selecting their fertilizers with reference to the wants of the crops they wish to cultivate, the writer has for years published in his annual reports a compilation of the analyses of farm and garden crops, to serve as a guide to all interested in a rational mode of manuring plants. Copies of these compilations of analyses may be secured by asking for them at the office of the Hatch Experiment Station at Amherst, Mass.

An economical use of manurial substances from any source is only possible after the local condition of the soil under consideration, as well as the special wants of the crops to be raised, have been duly considered. It becomes the business of every progressive farmer to acquire such information as is called for to select intelligently, from the various manurial resources at his disposal, those materials which will meet best his wants for a complete fertilizer.

In making choice from among the so-called complete fertilizers, two points seem to be in particular worth remembering. First, select them with reference to the amount, the quality and the kind of essential constituents they are guaranteed to contain, and not merely with reference to cost per ton; mere trade names are no guarantee of fitness. High-priced articles, when offered by reputable manufacturers, have proved in many instances cheaper than low-priced goods. Second, buy your supplies of reputable dealers, and insist in all cases on a statement of guaranteed composition.

The majority of manufacturers and dealers in commercial fertilizers in Massachusetts have been for years on record, regarding the character of their goods, in the published re-

ports of the State inspector, which are open to the public; to these records this office invariably refers all parties asking for information in that direction.

Valuation of Commercial Fertilizers.

The market value of the higher grades of agricultural chemicals and compound fertilizers depends in the majority of cases on the amount and the particular form of three essential articles of plant food which they contain, *i.e.*, nitrogen, potash and phosphoric acid. Supply and demand control the temporary market prices not less in the fertilizer trade than in other lines of commercial business.

The approximate market value of a fertilizer, simple or compound, is obtained by multiplying the pounds contained in a ton of two thousand pounds by the trade value per pound of each of the three above-stated essential constituents of plant food present. The same course is adopted with reference to the different forms of each, wherever different prices are recognized in the trade. Adding the different values per ton obtained, we find the total value per ton at the principal place of distribution.

As farmers are quite frequently not in the position to secure the desired information regarding the market cost of fertilizers they wish to secure, the official inspectors of commercial fertilizers have aided them for years in ascertaining the current market prices of the following leading or standard raw materials: —

Sulphate of ammonia.	Ammoniate.
Nitrate of soda.	Castor pomace.
Muriate of potash.	Linseed meal.
Sulphate of potash.	Dried blood.
Cotton-seed meal.	Dried ground meat.
Dry ground fish.	Bone and tankage.
Azotin.	Plain superphosphates, etc.

Which serve largely in the manufacture of good fertilizers for our market; and have published the results of their inquiries in form of tables, stating the average trade values per pound, for the six months preceding, of the different kinds and forms of fertilizing materials at the leading places of distribution.

The market value of fertilizing ingredients, like other merchandise, is liable to changes during the season. The values stated below are based on the condition of the fertilizer market in centres of distribution in New England during the six months preceding March, 1897: —

Trade Values of Fertilizing Ingredients in Raw Materials and Chemicals, 1897 (Cents per Pound).

Nitrogen in ammonia salts,	13.5
Nitrogen in nitrates,	14.0
Organic nitrogen in dry and fine-ground fish, meat, blood and in high-grade mixed fertilizers,	14.0
Organic nitrogen in cotton-seed meal, linseed meal and in castor pomace,	12.0
Organic nitrogen in fine-ground bone and tankage,	13.5
Organic nitrogen in medium-ground bone and tankage,	11.0
Organic nitrogen in coarse bone and tankage,	8.0
Phosphoric acid soluble in water,	5.5
Phosphoric acid soluble in ammonium citrate,	5.0
Phosphoric acid in fine bone and tankage,	5.0
Phosphoric acid in medium bone and tankage,	4.0
Phosphoric acid in coarse bone and tankage,	2.5
Phosphoric acid in fine-ground fish, cotton-seed meal, linseed meal, castor pomace and wood ashes,	5.0
Phosphoric acid insoluble (in am. cit.) in mixed fertilizers,	2.0
Potash as sulphate, free from chlorides,	5.0
Potash as muriate,	4.5

From these figures it is apparent that the best forms of nitrogen and phosphoric acid have suffered a material reduction in cost, as compared with preceding years.

The market value of low-priced materials used for manurial purposes, as salt, wood ashes, various kinds of lime, barn-yard manure, factory refuse and waste materials of various description, quite frequently does not stand in a close relation to the current market value of the amount of essential articles of plant food they contain. Their cost varies in different localities. Local facilities for cheap transportation, and more or less advantageous mechanical conditions for speedy action, exert, as a rule, a decided influence on their selling price.

The mechanical condition of any fertilizing material, simple or compound, deserves the most serious consideration of farmers when articles of a similar chemical character are

offered for their choice. The degree of pulverization controls, almost without exception, under similar conditions, the rate of solubility, and the more or less rapid diffusion of the different articles of plant food throughout the soil.

The state of moisture exerts a no less important influence on the pecuniary value in case of one and the same kind of substance. Two samples of fish fertilizers, although equally pure, may differ from fifty to one hundred per cent. in commercial value, on account of mere difference in moisture.

Crude stock for the manufacture of fertilizers, and refuse materials of various descriptions, have to be valued with reference to the market price of their principal constituents, taking into consideration at the same time their general fitness for speedy action.

Consumers of commercial manurial substances will do well to buy, whenever practicable, on a guarantee of composition of their essential constituents, and to see to it that the bill of sale recognizes the point of the bargain. Any mistake or misunderstanding in the transaction may be readily adjusted, in that case, between the contending parties. The responsibility of the dealer ends with furnishing an article corresponding in its composition with the lowest stated quantity of each specified essential constituent.

It is of the first importance, when buying fertilizers for home consumption, to consider their cost with reference to what they promise to furnish.

List of Manufacturers and Dealers who have secured Certificates for the sale of Commercial Fertilizers in the State during the Past Year (May 1, 1897, to May 1, 1898) and the Brands licensed by Each.

The Armour Fertilizer Works, Chicago, Ill.: —
- Bone Meal.
- Bone and Blood.
- Ammoniated Bone and Potash.
- All Soluble.
- Bone, Blood and Potash.
- Grain Grower.

American Fertilizer Co., Boston, Mass.: —
- Alkali Nitrate Phosphate for Hoed Crops.

American Fertilizer Co. — *Con.*
- Alkali Nitrate Phosphate for Grass and Grain.
- General American Fertilizer.
- Potato Fertilizer.

Wm. H. Abbott, Holyoke, Mass.: —
- Eagle Brand for Grass and Grain.
- Complete Tobacco Fertilizer.
- Animal Fertilizer.

American Cotton Oil Co., New York, N. Y.: —
- Cotton-seed Meal.

Bartlett & Holmes, Springfield, Mass.: —
Pure Ground Bone.
Animal Fertilizer.
Tankage.

H. J. Baker & Bro., New York, N. Y.: —
Pure Ground Bone.
Standard Un X Ld Fertilizer.
Strawberry Manure.
Potato Manure.
Tobacco Manure.
Grass and Grain Manure.
A. A. Ammoniated Superphosphate.
Harvest Home Fertilizer.

C. A. Bartlett, Worcester, Mass.: —
Fine-ground Bone.
Animal Fertilizer.

Berkshire Mills Co., Bridgeport, Conn.: —
Complete Fertilizers.
Ammoniated Bone Phosphate.

Bowker Fertilizer Co., Boston, Mass.: —
Stockbridge Special Manures.
Hill and Drill Phosphate.
Farm and Garden Phosphate.
Lawn and Garden Dressing.
Fish and Potash.
Potato and Vegetable Manure.
Potato Phosphate.
Market Garden Manure.
Sure Crop Phosphate.
Gloucester Fish and Potash.
High-grade Fertilizer.
Essex Fertilizer.
Bone and Wood Ash Fertilizer.
Nitrate of Soda.
Dried Blood.
Dissolved Bone-black.
Muriate of Potash.
Sulphate of Potash.

William E. Brightman, Tiverton, R. I.: —
Potato and Root Manure.
Phosphate.
Fish and Potash.

Bradley Fertilizer Co., Boston, Mass.: —
X. L. Superphosphate.
Potato Manure.
B. D. Sea Fowl Guano.
Complete Manures.
Fish and Potash.
High-grade Tobacco Manure.
English Lawn Fertilizer.
Ammoniated Bone Phosphate.
Breck's Lawn and Garden Dressing.
Sulphate of Potash.

Bradley Fertilizer Co. — *Con.*
Muriate of Potash.
Nitrate of Soda.
Sulphate of Ammonia.
Dissolved Bone-black.
Fine-ground Bone.

Daniel T. Church, Providence, R. I. (E. Wilcox, general agent): —
Church's B Special.
Church's C Standard.
Church's D Fish and Potash.

The Cleveland Linseed Oil Co., Cleveland, O.: —
Screened Linseed Meal.

Clark's Cove Fertilizer Co., Boston, Mass.: —
Bay State Fertilizer.
Bay State Fertilizer G. G. Brand.
Great Planet Manure.
Potato and Tobacco Fertilizer.
King Philip Guano.
Potato Manure.
Fish and Potash.
White Oak Pure Bone Meal.

Cleveland Dryer Co., Boston, Mass.: —
Superphosphate.
Potato Phosphate.
Cleveland Fertilizer.

E. Frank Coe Co., New York, N. Y.: —
High-grade Potato Fertilizer.
Bay State Ammoniated Bone Superphosphate.
Bay State Potato Manure.
High-grade Ammoniated Bone Superphosphate.
Gold Brand Excelsior Guano.
Fish Guano and Potash.

Crocker Fertilizer and Chemical Co., Buffalo, N. Y.: —
Ammoniated Bone Superphosphate.
Potato, Hop and Tobacco Phosphate.
Ammoniated Wheat and Corn Phosphate.
New Rival Ammoniated Superphosphate.
Practical Ammoniated Superphosphate.
Vegetable Bone Superphosphate.
General Crop Phosphate.
Universal Grain Grower.
Special Potato Manure.
New England Tobacco and Potato Grower.

Crocker Fertilizer and Chemical Co. — *Con.*
Coolidge Bros. Special Truck Fertilizer.
A. A. Complete Manure.
Ground Bone Meal.
Pure Ground Bone.
Muriate of Potash.
Nitrate of Soda.

Cumberland Bone Phosphate Co., Boston, Mass.: —
Superphosphate.
Potato Fertilizer.
Concentrated Phosphate.
Guano.

City Florist, Brockton, Mass.: —
Boo Boo Plant Food.

L. B. Darling Fertilizer Co., Pawtucket, R. I.: —
Animal Fertilizer.
Potato and Root Crop Manure.
Lawn Dressing.
Tobacco Grower.
Blood, Bone and Potash.
Special Formula.
Fine-ground Bone.
Muriate of Potash.
Nitrate of Soda.

John C. Dow & Co., Boston, Mass.: —
Ground Bone Fertilizer.
Nitrogenous Superphosphate.
Pure Ground Bone.

W. E. Fife & Co., Clinton, Mass.: —
Wood Ashes.

Great Eastern Fertilizer Co., Rutland, Vt.: —
Northern Corn Special.
General Fertilizer.
Vegetable Vine and Tobacco Fertilizer.
Garden Special.
Soluble Bone and Potash.

Thomas Hersom & Co., New Bedford, Mass.: —
Bone Meal.
Meat and Bone.

Alonzo P. Henderson, Hanover, Mass.: —
Acme Brand Fertilizer.

Edmund Hersey, Hingham, Mass.: —
Ground Bone.

John G. Jefferds, Worcester, Mass.: —
Animal Fertilizer.
Potato Manure.
Fine-ground Bone.

Thomas Joint, St. Helen, Ontario, Can.: —
Unleached Hard-wood Ashes.

Thomas Kirley, South Hadley Falls, Mass.: —
Pride of the Valley.

A. Lee & Co., Lawrence, Mass.: —
Lawrence Fertilizer.

Lowell Fertilizer Co., Boston, Mass.: —
Bone Fertilizer for Corn and Grain.
Complete Manure for Vegetables.
Animal Fertilizer.
Potato Phosphate.
Bone and Potash.
Lawn Dressing.
Tobacco Manure.
Empire Fertilizer.

Lowe Bros. & Co., Fitchburg, Mass.: —
Tankage.

F. L. Lalor, Dunville, Ontario, Can.: —
Canada Unleached Hard-wood Ashes.

The Mapes Formula and Peruvian Guano Co., New York, N. Y.: —
Bone Manures.
Superphosphates.
Special Crop Manures.
Sulphate of Potash.
Double Manure Salts.
Nitrate of Soda.

E. McGarvey & Co., London, Ontario, Can.: —
Unleached Hard-wood Ashes.

McQuade Bros., West Auburn Mass.: —
Fine-ground Bone.

Geo. L. Monroe, Oswego, N. Y.: —
Canada Unleached Hard-wood Ashes.

National Fertilizer Co., Bridgeport, Conn.: —
Complete Fertilizers.
Ammoniated Bone.

National Fertilizer Co. — *Con.*
Market-garden Manure.
Potato Phosphate.
Fish and Potash.
Ground Bone.

Niagara Fertilizer Works, Buffalo, N. Y.: —
Wheat and Corn Producer.
Grain and Grass Grower.
Potato, Tobacco and Hop Fertilizer.
Niagara Triumph.

New England Dressed Meat and Wool Co., Boston, Mass.: —
Sheep Fertilizer.

Packers Union Fertilizer Co., New York, N. Y.: —
Universal Fertilizer.
Wheat, Oats and Clover Fertilizer.
Animal Corn Fertilizer.
Potato Manure.
Gardener's Complete Manure.

Pacific Guano Co., Boston, Mass: —
Soluble Pacific Guano.
Special Potato Manure.
Special for Potatoes and Tobacco.
Nobsque Guano.
High-grade General Fertilizer.

Parmenter & Polsey Fertilizer Co., Peabody, Mass.: —
Plymouth Rock Brand.
Star Brand Fertilizer.
Butman Brand Fertilizer.
Special Potato.
Strawberry.
Ground Bone.
Muriate of Potash.
Sulphate of Potash.
Nitrate of Soda.

A. W. Perkins & Co., Rutland, Vt.: —
Plantene.

Prentiss, Brooks & Co., Holyoke, Mass.: —
Complete Manures.
Phosphate.
Nitrate of Soda.
Muriate of Potash.
Sulphate of Potash.

Preston Fertilizer Co., Brooklyn, N. Y.: —
Ammoniated Bone Superphosphate.

Quinnipiac Co., Boston, Mass.: —
Phosphate.
Potato Manure.
Market-garden Manure.
Fish and Potash.
Havana Tobacco Grower.
Grass Fertilizer.
Corn Manure.
Potato Phosphate.
Onion Manure.
Pure Ground Bone.
Dry Ground Fish.
Muriate of Potash.
Sulphate of Potash.
Nitrate of Soda.
Sulphate of Ammonia.
Dissolved Bone-black.

Read Fertilizer Co., New York, N. Y. (H. D. Foster, general agent): —
Standard Fertilizer.
High-grade Farmers' Friend.
Practical Potato Special.
Farmer's Friend,
Vegetable and Vine.

N. Roy & Son, South Attleborough, Mass.: —
Complete Animal Fertilizer.

The Rogers & Hubbard Co., Middletown, Conn.: —
Soluble Potato Manure.
Soluble Tobacco Manure.
Fairchild's Formula for Corn and General Crops.
Fruit Fertilizer.
Grass and Grain Fertilizer.
Oats and Top-dressing Fertilizer.
Pure Raw Knuckle Bone Flour.
Strictly Pure Fine Bone.
Fertilizer for all Soils and all Crops.

Russia Cement Co., Gloucester, Mass.: —
X X X Fish and Potash.
High-grade Superphosphate.
Corn, Grain and Grass Manure.
Potato, Root and Vegetable Manure.
Special Tobacco Fertilizer.
Odorless Lawn Dressing.

Lucien Sanderson, New Haven, Conn.: —
Formula A.
Blood, Bone and Meat.
Dissolved Bone-black.
Nitrate of Soda.
Sulphate of Potash.
Muriate of Potash.

Edward H. Smith, Northborough, Mass.: —
Ground Bone.

J. Stroup & Son Co., Boston, Mass.: —
Hard-wood Ashes.

Thomas L. Stetson, Randolph, Mass.: —
Ground Bone.

Standard Fertilizer Co., Boston, Mass.: —
Standard Fertilizer.
Potato and Tobacco Fertilizer.
Standard Guano.
Complete Manure.
Fine-ground Bone.

C. F. Sturtevant, Hartford, Conn: —
Tobacco and Sulphur Fertilizer.

Henry F. Tucker, Boston, Mass.: —
Original Bay State Bone Superphosphate.
Imperial Bone Superphosphate.
Special Potato Fertilizer.

I. P. Thomas & Son Co., Philadelphia, Pa.: —
Martin's Bone Mixture.
So. Carolina Phosphate with Potash.
So. Carolina Phosphate.
Pure Ground Animal Bone.
Steamed Bone.
Improved Superphosphate.
Potato and Tomato Manure.
Normal Bone Phosphate.
Farmer's Choice Bone Phosphate.
Tobacco Fertilizer.

Walker, Stratman & Co., Pittsburg, Pa.: —
Potato Special.
Big Bonanza.
Smoky City.
Four Fold.

Andrew H. Ward, Boston, Mass.: —
Ward's Chemical Fertilizer.

I. S. Whittemore, Wayland, Mass.: —
Complete Manure.

D. Whithed, Lowell, Mass.: —
Champion Fertilizer.
Bone Meal.

The Wilcox Fertilizer Works, Mystic Conn.: —
Potato, Onion and Tobacco Manure.
Ammoniated Bone Phosphate.
High-grade Fish and Potash.
Dry Ground Fish Guano.

Williams & Clark Fertilizer Co., Boston, Mass.: —
Ammoniated Bone Superphosphate.
Potato Phosphate.
High-grade Special.
Fine Wrapper Tobacco Grower.
Royal Bone Phosphate.
Corn Phosphate.
Potato and Tobacco Manure.
Grass Manure.
Fish and Potash.
Universal Ammoniated Dissolved Bone.
Prolific Crop Producer.
Onion Manure.
Bone Meal.
Dry Ground Fish.
Sulphate of Potash.
Muriate of Potash.
Nitrate of Soda.
Dissolved Bone-black.
Sulphate of Ammonia.

M. E. Wheeler & Co., Rutland, Vt.: —
High-grade Corn Fertilizer.
High-grade Potato Manure.
Superior Truck Fertilizer.
Havana Tobacco Grower.
High-grade Fruit Fertilizer.
High-grade Grass and Oats Fertilizer.
Electrical Dissolved Bone.

II. REPORT ON GENERAL WORK IN THE CHEMICAL LABORATORY.

CHARLES A. GOESSMANN.

1. Analyses of Materials sent on for Examination.
2. Notes on Barn-yard Manure.
3. Notes on Wood Ashes.
4. Notes on Cotton-seed Meal.
5. Notes on Guano from West Coast of Africa.
6. Notes on Ashes from Crematory Furnace for City Garbage.
7. Notes on Wool Washings.

1. Analyses of Materials sent on for Examination.

The work carried on in this connection is growing from year to year in importance. A large proportion of commercial manurial substances consists of by or waste products of various industries. The composition and general character of these materials depend on the current mode of manufacture. The rapid advancement in many branches of industries is at any time liable to affect more or less seriously the commercial as well as the manurial value of their waste products. A frequent examination of that class of materials cannot fail to benefit the vital interests of our farming community. For this reason arrangements were made, as in previous years, to attend to the examination of substances of interest to farmers to the full extent of the resources placed at the disposal of the officer in charge of this work. These investigations are carried on free of charge to farmers of the State. The results are considered public property, and are published from time to time in the bulletins of the station.

The number of substances tested in this connection amount to two hundred and thirty-eight. As the detailed results of

their analyses have already been published in three bulletins, Nos. 45, 48 and 49, March, July and November, 1897, a brief statement of the names of the different articles analyzed will, on this occasion, suffice to convey some idea of the extent and the character of the work accomplished. Only a few of these materials of more special importance are reserved for a subsequent short discussion.

The substances tested from Dec. 1, 1897, to Dec. 1, 1898, are as follows: wood ashes, 89; cotton-seed meal, 23; cotton-seed hull ashes, 3; cotton factory waste, 5; tankage, bone and fish, 17; muck, peat and soils, 16; chemicals, 14; acid phosphates and dissolved bone-blacks, 5; natural phosphates, 6; tobacco refuse, 2; complete fertilizers, 31; miscellaneous, 9; Damara land guano, garbage cremation ashes and wool washings, each 1.

Aside from this work are the complete analyses of 36 samples of tobacco leaves, together with numerous tests for the quality of ash and rate of combustion. See Bulletin No. 47, on tobacco experiments, published in April, 1897.

The responsibility of the genuineness of all articles sent on for examination rests with the parties asking for the analysis. Our publications of the results refer merely to the locality they come from, to avoid misunderstandings. Samples of fertilizers collected from original packages by authorized agents of the station in the general markets furnish the material for official analyses, and are considered genuine articles.

2. Notes on Barn-yard Manure.

The importance of barn-yard manure as a home source of plant food cannot be over-estimated in a mixed farm management. In a well-regulated rational system of stock feeding it is one of the cheapest if not the cheapest source of valuable manurial constituents. An exceptional liability to vary in composition is the strongest objection which can be raised against its exclusive use as a manure supply for the farm and garden, yet this objection has lost much of its force since the causes of variation are better understood, and may thus be avoided to a considerable extent. We have learned

how to improve its efficiency as a complete manure under varying conditions of soil as well as of varying wants of crops, by adding those manurial constituents which are called for in different relative proportions, and which the barn-yard manure on hand does not contain.

Analyses of Eighty Samples of Barn-yard Manure made at Amherst, Mass.

ANALYSIS.	POUNDS PER HUNDRED.			Pounds per Ton (2,000 Pounds).
	Highest.	Lowest.	Average.	
Moisture, ...	75.00	60.00	67.24	1344.80
Nitrogen, ...	1.36	.21	.52	10.40
Potassium oxide, . . .	1.40	.13	.56	11.20
Phosphoric acid, . . .	.75	.10	.39	7.80

The average barn-yard manure contains, as will be noticed from the above statement, a larger percentage of nitrogen as compared with potash and phosphoric acid than is generally considered economical in a complete fertilizer for general farm purposes.

The practice of adding to the manurial refuse materials of the farm, as stable manure, vegetable compost, etc., such single commercial manurial substances as will enrich them in the direction desirable for any particular crop, does not yet receive that degree of general attention which it deserves. An addition of potash in the form of muriate or sulphate of potash, or of phosphoric acid in the form of fine-ground South Carolina or Florida soft phosphate, etc., will in many instances not only improve their general fitness as complete manure, but quite frequently permit a material reduction in the amount of barn-yard manure ordinarily considered necessary to secure satisfactory results. An addition of from thirty to forty pounds of muriate of potash and one hundred pounds of fine-ground soft Florida phosphate per ton of barn-yard manure, at any time before applying the latter to the soil deserves recommendation.

3. Notes on Wood Ashes.

Forty per cent. of all articles sent on for examination consist of wood ashes. They are sold in the majority of cases under the trade name "Unleached Canada hard-wood ashes." Ninety-eight samples tested at the station during the past year gave the following results: —

	No. of Samples.
Moisture from 1 to 3 per cent.,	10
" 4 to 6 "	8
" 6 to 10 "	13
" 10 to 15 "	19
" 15 to 20 "	11
" 20 to 30 "	10
Moisture above 35 per cent.,	1
Potassium oxide above 8 per cent.,	3
" " from 7 to 8 per cent.,	8
" " " 6 to 7 "	21
" " " 5 to 6 "	28
" " " 4 to 5 "	10
" " " 3 to 4 "	3
" " below 3 per cent.,	none
Phosphoric acid above 2 "	4
" " from 1 to 2 per cent.,	45
" " below 1 per cent,	24
Average per cent. of calcium oxide (lime),	34.29
Per cent. mineral matter insoluble in diluted hydrochloric acid, from — 6 to 10,	10
10 to 15,	30
15 to 20,	15
20 to 30,	3
above 30,	1

The variations noticeable in the composition of wood ashes are not surprising when we consider the crude mode of collecting and handling them for commercial purposes. The particular effects of both varying quantities of foreign insoluble matter, as soil, coal ashes, etc., and of moisture, on the composition of a given sample of genuine wood ashes, as far as its percentage of potash and of phosphoric acid is concerned, depend largely on the particular kind of wood which has served for the production of the ash. The color of the wood ashes in case of dark varieties depends usually on admixture of more or less charcoal, while an exceptionally light color is not unfrequently due to the kind of wood which furnishes it. Some kinds of wood, as elm

wood, produce a white ash of excellent quality, judging from samples sent on for examination.

As the dealer is only obliged to guarantee the amount of potash and of phosphoric acid present in a given quantity of wood ashes, no serious objection can be raised on the part of the buyer on account of moisture, etc., as long as the article contains the specified amount of both potash and phosphoric acid.

Wood ashes ought to be bought and sold by weight, and not by measure, for both moisture and foreign matters are apt to affect seriously the weight of a given measure.

Some dealers in wood ashes have adopted of late the practice of stating merely the sum of both, instead of specifying the amount of each of them present. As phosphoric acid and potassium oxide contained in wood ashes are considered in our section of the country, pound for pound of an equal commercial value, from 4.5 to 5 cents, no particular objection can be raised against a joint statement of both as far as the mere money value of the samples is concerned; yet, as this mode of stating the guaranteed composition is apt to lead to misconception and abuse, it ought to be discouraged and discontinued.

The large percentage of lime, from 30 to 40 per cent., found in genuine wood ashes, imparts a special agricultural value to them as a fertilizer, aside from the amount of potash and phosphoric acid they contain. Wherever an application of lime is desired, wood ashes deserve favorable consideration, on account of the superior mechanical condition of the lime they furnish.

4. Notes on Cotton-seed Meal as a Fertilizer.

Recent low prices of some concentrated feed stuffs have favored experiments to test their fitness for supplying directly nitrogen, phosphoric acid and potash for plant food. Whenever the market value of the amount of nitrogen, phosphoric acid and potash they contain compares fairly well with the market cost of these three ingredients, the trials deserve, for various reasons, encouragement.

The richness of cotten-seed meal, linseed meal, etc., as well as their marked disposition to rot in the presence of

moisture and of a fair average temperature, caused their selection. Both are quite frequently looked upon with favor as suitable materials to furnish plant food for various farm crops. Cotton-seed meal in particular is to-day used extensively by tobacco growers in the Connecticut River valley as the main source of nitrogen for that crop.

The increasing importance of cotton-seed meal as a fertilizer has been followed by the writer with a frequent examination of the articles sold in our markets to protect the interests of our farmers. Importers of cotton-seed meal, claiming that they sold their articles as a feed stuff and not as a fertilizer, declined as a rule until quite recently to take out a fertilizer license which would oblige them to sell with a stated guarantee of at least the nitrogen.

The results of sixty-five analyses carried on under my direction are as follows: —

	Per Cent.		
	Maximum.	Minimum.	Average.
Moisture, ...	10.80	3.90	7.00
Nitrogen, ...	7.95	2.08	6.60
Phosphoric acid, ...	3.36	.73	1.79
Potassium oxide, ...	2.38	.48	1.76

Allowing 12 cents for every pound of nitrogen, 5 cents per pound for each of phosphoric acid and potassium oxide, these three ingredients represent per ton a market value of —

$19.39 in case of our average sample of cotton-seed meal.
24.82 in case of our highest sample of cotton-seed meal.
6.20 in case of our lowest sample of cotton-seed meal.

The above-stated difference in the composition of cotton-seed meal is mainly due to the presence of more or less ground skins and husks of the cotton seed. Cotton-seed meal designed for fodder ought to be free from skins and husks, to deserve a recommendation for that purpose; cotton-seed meal to be used for fertilizer may contain more or

less of this substance, provided the entire material is finely ground and the price in accordance with the composition.

We advise farmers to buy cotton-seed meal, like all other fertilizing materials, on the basis of a guarantee of (at least) nitrogen as the basis of the bargain. For their information it seems but proper to state in this connection that the American Cotton Oil Company of New York has quite recently secured a license for the sale of their cotton-seed meal as a fertilizer in our State, and intend to sell on the basis of the amount of nitrogen their article contains.

5. Notes on Damara Land Guano.

The material which served for our examination was sent on to this office by Messrs. H. J. Baker & Bro. of New York City. It consisted of a bag containing two hundred pounds of guano, and was accompanied by analyses of two chemists of London, Eng. As every new source of a genuine guano claiming to resemble the Peruvian guano of earlier periods in the trade of commercial fertilizers must be of special importance to all interested in the temporary resources of our supplies of plant food, our results are briefly stated below: —

Analysis of Damara Land Guano (*Per Cent.*).

Moisture at 100° C.,	17.70
Organic matter,	25.63
Total ash,	56.67
Total nitrogen,	5.79
Nitrogen in form of ammoniates,	1.80
Nitrogen in form of nitrates,	.05
Nitrogen in form of organic matter,	3.94
Carbonic acid,	trace
Total phosphoric acid,	14.78
Soluble phosphoric acid,	4.90
Reverted phosphoric acid,	5.79
Insoluble phosphoric acid,	4.09
Total potassium oxide,	3.53
Potassium oxide soluble in water,	3.46
Sodium oxide,	7.03
Calcium oxide,	14.21
Magnesium oxide,	2.05
Iron and aluminum oxides,	trace
Sulphuric acid,	5.94
Chlorine,	5.77
Insoluble matter,	9.26

The results of our analyses of the sample (two hundred pound bag) kindly sent on for trial by Messrs. H. J. Baker & Bro., New York City, are fairly within the stated composition of English chemists. The guano, it is stated, has been brought from some islands off the west coast of Africa; it is a valuable material, as may be seen from our detailed statement.

6. Notes on Crematory Ashes from City Garbage.

In my annual report for 1895 (pages 160 and 161), special attention was called to two important recent modes of saving city garbage, kitchen refuse in particular, for manurial purposes. Sanitary considerations are the first cause of the introduction of these new modes of disposing of objectionable refuse matter, which promise to become from day to day more important as supplies of valuable fertilizer materials.

Our attention has been in particular called to the products of the crematory furnace ashes from Lowell, Mass. The article is evidently improving, in consequence of the adoption of a proper system of sifting and grinding the ashes, as will be seen from the accompanying analysis, representing, according to statement, one hundred tons. The selling price, from $10 to $11 per ton, invites serious trials, as a fertilizer furnishing potash, phosphoric acid and lime.

Analysis of Ashes from the Cremation of City Garbage (Per Cent.).

Moisture at 100° C.,	.53
Potassium oxide,	6.01
Sodium oxide,	15.65
Total phosphoric acid,	10.21
Available phosphoric acid,	2.34
Insoluble phosphoric acid,	7.87
Sulphuric acid (So_3),	4.57
Chlorine,	4.75
Carbonic acid (CO_2),	10.85
Calcium oxide,	20.22
Magnesium oxide,	1.16
Iron and alumina,	9.32
Insoluble matter,	24.26
Nitrogen (inactive lyan compounds),	.17

7. Notes on Wool Washings as a Source of Fertilizer.

It is a well-known fact that the skins of sheep and raw wool are coated with potash compounds of a soap-like nature. In many localities in Europe it is a common practice to turn to account for manuring grass lands the water used in washing sheep before shearing, as well as the wash water obtained from raw wool in factories. This is used in form of an overflow. Wherever meadows adjoin the place of washing wool, arrangements may be readily provided for turning the wool washings directly to account. Samples of raw wool tested here for potash some years ago gave the following results: —

Potassium oxide soluble in water (per cent.),	3.92
Potassium oxide soluble in diluted hydrochloric acid (per cent.),	4.20

Of interest in this connection are the results of examination of a material sent on from a factory in this State. The article was labelled "concentrated potash liquor," and described as obtained from the washings of wool with water after the grease had been extracted by naphtha. It consisted of a highly colored, thick, syrup-like mass, containing a liberal admixture of fine fibrous vegetable matter. An analysis made with reference to its approximate value as a fertilizer gave the following results: —

	Per Cent.
Moisture at 100° C.,	41.13
Dry matter,	58.87

The dry matter left behind contained: —

	Per Cent.
Potassium oxide,	10.15
Phosphoric acid,	.10
Nitrogen,	1.09

The commercial value of these ingredients per ton of the original substance at the present rates amounts approximately to $12.40. In charring the original material directly, 100 parts left behind 36.49 parts; the charred mass tested for potassium oxide showed 34.91 per cent. present, or 698.2 pounds of potassium oxide per ton of charred residue, which

equals 1,012 pounds of carbonate of potash per ton of charred residue practically free from chlorine.

The scarcity of a good quality of carbonate of potash for manurial purposes in case of tobacco and similar industrial crops ought to encourage attempts to turn the concentrated potash liquor to account.

The charred mass might serve directly as material for the manufacture of a high-grade potash fertilizer.

III. NOTES OF FIELD EXPERIMENTS WITH TOBACCO IN MASSACHUSETTS, 1893–96.

CHARLES A. GOESSMANN.

The experiments briefly described in the following pages were carried on with the co-operation of the Valley Tobacco Experiment Association of Massachusetts.

The officers of this organization consisted of President L. A. Crafts of Whately, Vice-President C. L. Fowler of Westfield, Secretary and Treasurer G. D. Fisk of Agawam; Board of Directors, W. A. Porter of Agawam and C. L. Warner of Hatfield.

Hatfield, Westfield and Agawam were chosen for the location of the experiments. The selection of the particular field in each place was left to a special committee of the association. In all cases a deep, sandy loam was selected for the trial.

The same kind and the same amount of fertilizing ingredients were used in all cases, and the observations continued for three successive years. For details see Bulletin No. 47, April, 1897.

The variety of tobacco selected for the trial was Havana seed. For the purpose of securing uniformity of fertilizer during the years of the experiment, it was decided to purchase at once, as far as advisable, enough of each kind to supply the needed materials for three years.

Statement of Fertilizers used upon Different Plots.

The fertilizer mixture used during the entire time of observation contained in all cases, per acre: —

	Pounds.
Potassium oxide (available)	300
Nitrogen (available), ...	100
Phosphoric acid (available), ...	60

One-fourth of the nitrogen was in all cases used in the form of nitrates of soda or potash, to secure a uniform con-

dition of availability of nitrogen during the early stages of growth.

Each experiment plot measured 3,634 square feet, or approximately one-twelfth of one acre.

Chemical Composition of the Different Fertilizing Ingredients used in compounding the Special Fertilizers for Different Plots in the Tobacco Experiment. Ingredients containing Chlorine were carefully excluded from the Mixtures of Fertilizers in All Cases.

NAME OF MATERIAL.	Nitrogen.	Phosphoric Acid.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.
Nitrate of soda,	15.59	–	–	35.00	–	–
Nitrate of potash,	12.79	–	45.05	–	–	–
Cotton-seed meal,	6.50	3.17	2.25	–	–*	–*
Linseed meal,	5.91	1.95	1.08	–	–*	–*
Castor pomace,	5.60	2.26	3.40	–	–*	–*
Dissolved bone-black,	–	13.38	–	–	–*	–
Odorless phosphate, or phosphatic slag,	–	18.42	–	–	48.27	–
High-grade sulphate of potash,	–	–	50.20	–	–	–
Potash-magnesia sulphate,	–	–	24.32	–	–	12.58
Cotton-seed hull ashes,	–	7.93	23.96	–	9.30	10.47
Carbonate of potash-magnesia,	–	–	18.48	–	–	19.52
Barn-yard manure,	.52	.39	.56	–*	–*	–*

* Not determined.

Chemical Composition of the Different Special Formulas used in the Tobacco Experiment.

Plot 1.

NAME OF FERTILIZING MATERIAL USED.	Pounds per Acre.	Pounds of Fertilizing Elements per Acre.		
		Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Nitrate of potash,	195	–	88	25
Cotton-seed meal,	1,154	37	26	75
Dissolved bone-black,	175	23	–	–
Potash-magnesia sulphate,	765	–	186	–
Total,	–	60	300	100

PLOT 2.

NAME OF FERTILIZING MATERIAL USED.	Pounds per Acre.	POUNDS OF FERTILIZING ELEMENTS PER ACRE.		
		Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Nitrate of potash,	195	–	88.0	25
Castor pomace,	1,340	31	45.0	75
Dissolved bone-black,	221	29	–	–
Potash-magnesia sulphate,	685	–	166.5	–
Total,	–	60	299.5	100

PLOT 3.

Nitrate of soda,	160.3	–	–	25
Cotton-seed meal,	1,154.0	37.00	26	75
Cotton-seed hull ashes,	1,142.0	90.56	274	–
Total,	–	127.56	300	100

PLOT 4.

Nitrate of soda,	160.3	–	–	25
Castor pomace,	1,340.0	31.0	45.50	75
Cotton-seed hull ashes,	1,060.0	84.1	253.97	–
Total,	–	115.1	299.47	100

[PLOT 5.—No manure at any time during the experiment.]

PLOT 6.

Nitrate of soda,	160.3	–	–	25
Cotton-seed meal,	1,154.0	37	26	75
Dissolved bone-black,	175.0	23	–	–
High-grade sulphate of potash,	545.8	–	274	–
Total,	–	60	300	100

Plot 7.

Name of Fertilizing Material Used.	Pounds per Acre.	Pounds of Fertilizing Elements per Acre.		
		Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Nitrate of soda,	160.3	–	–	25
Castor pomace,	1,340.0	31	45.50	75
Dissolved bone-black,	221.0	29	–	–
High-grade sulphate of potash,	506.0	–	254.50	–
Total,	–	60	300.00	100

Plot 8.

Nitrate of soda,	160.3	–	–	25
Linseed meal,	1,271.0	24.78	14	75
Dissolved bone-black,	263.0	35.22	–	–
High-grade sulphate of potash,	569.7	–	286	–
Total,	–	60.00	300	100

Plot 9.

Nitrate of potash,	195	–	88	25
Cotton-seed meal,	1,154	37	26	75
Cotton-seed hull ashes,	776	62	186	–
Total,	-	99	300	100

Plot 10.

Nitrate of potash,	195.0	–	88.00	25
Castor pomace,	1,340.0	31	45.50	75
Phosphatic slag meal,	157.0	29	–	–
Carbonate of potash-magnesia,	900.9	–	166.50	–
Total,	–	60	300.00	100

Plots 11 and 12. *

Barn-yard manure,	20,000	78	112	104

* Average analysis of seventy-five samples tested at the station laboratory at Amherst, Mass.

Summary of Three Years of Observation at Hatfield, Agawam and Westfield.

I. Number of Plants harvested and Yield of Tobacco per One Thousand Plants.

Hatfield (Old Tobacco Land).

Year.	Average Number of Plants.		Difference in Yield per Plot on the Basis of 1,000 Plants (Pounds).	
	Per Plot.*	Per Acre.	Highest.	Lowest.
1893,	561	6,734	266	217
1894,	618	7,419	223	191
1895,	626	7,512	222	191

* One-twelfth of one acre.

Westfield (New Tobacco Land).

1894,	670	8,040	192	155
1895,	593	7,122	245	217
1896,	689	8,269	216	191

Agawam (New Tobacco Land).

1893,	696	8,352	225	158
1894,	704	8,432	220	164
1895,	695	8,340	222	148

Year.	Average Yield of Tobacco on the Basis of 1,000 Plants Harvested (Pounds).		
	Hatfield.	Westfield.	Agawam.
1893,	235.2	–	191.3
1894,	206.4	171.6	186.7
1895,	210.5	228.0	176.2
1896,	–	199.4	–

II. Average Yield of Tobacco, with Reference to Wrapper, per One Thousand Plants.

Hatfield.

YEAR.	Average Yield of Tobacco.	Average Yield of Wrappers.	Average Percentage of Wrappers.	Variations in Percentage of Wrappers in Plots.
	Pounds.	Pounds.		
1893, ...	235.2	97.2	41.2	21.0-71.0
1894, ...	206.6	105.0	50.7	38.8-64.4
1895, ...	210.1	109.3	52.1	36.8-63.1

Westfield.

1894, ...	171.3	90.3	52.3	41.6-62.10
1895, ...	228.7	49.6	21.2	6.4-34.40
1896, ...	199.3	138.2	69.6	59.0-78.80

Agawam.

1893, ...	190.8	-*	-*	-*
1894, ...	191.7	52.2	26.7	8.8-44.4
1895, ...	178.8	-*	-*	-*

* Not determined.

CONCLUSIONS DRAWN FROM THE THIRD YEAR OF OBSERVATION.

1. Good mechanical preparation of the soil and early application, and thus good diffusion of the fertilizers, not less than early planting and a suitable number of plants to a given area, exert a decided influence on the quantity and the quality of the crop, under otherwise corresponding conditions. Planting as early as the local climate admits secures the benefit of the winter moisture.

Too close planting interferes with a liberal or rapid development of the leaves, and too large open spaces between the

individual plants tends to favor a coarser structure. Rows three feet and four inches apart with plants twenty inches from each other in the row (Westfield), and rows two feet and eight inches apart with plants two feet from each other in the row (Hatfield) gave better returns than rows three feet apart with plants eighteen inches from each other in the row (Agawam).

2. A timely, shallow use of the cultivator or hoe for the removal of weeds favors a uniform progress of growth. A careless use of cultivator or hoe invariably checks more or less the growth of the plants, and modifies more or less their structure and general character.

3. The different fertilizer mixtures used in our experiments have affected in a less marked degree the weight of the crop raised by their aid than the quality. New lands reduced by previous cropping to a state approaching general exhaustion of available plant food, if otherwise well fitted for raising tobacco, have given excellent results when supplied with a suitable mixture of fertilizing ingredients in quantities similar to those applied during our experiments (Westfield). Such lands are at times preferable to old tobacco lands overcharged with remnants of all kinds of saline ingredients, usually associated with the common run of commercial fertilizers.

4. Cotton-seed meal, linseed meal and castor pomace have proved equally good sources of nitrogen for the successful raising of tobacco when used in connection with nitrate of soda or potash, sufficient to furnish one-fourth of the nitrogen called for by the crop.

5. Nitrate of soda as a part of the nitrogen supply in the fertilizer (25 per cent.), when used in presence of acid phosphate, dissolved bone-black, etc., has been accompanied with better results regarding quality of crop than nitrate of potash under otherwise similar conditions.

6. Cotton-seed hull ashes and high-grade sulphate of potash have proved in our observation most valuable sources of potash for tobacco, the former in the majority of cases leading. Nitrate of potash has produced excellent results when used in connection with an alkaline phosphate, as phosphatic slag meal or with carbonate of potash-magnesia. Our

results with potash-magnesia sulphate as the main potash sources of a tobacco fertilizer are not encouraging.

7. The difference noticed in the color of ash, etc., in case of the crop being raised upon different plots, is in several instances so slight that an attempt to classify the various fertilizers used with reference to their superior fitness on the basis of color and compactness of ash cannot be otherwise than arbitrary. With this qualification in mind, the following classification is offered for the consideration of parties engaged in the cultivation of tobacco in our section of the country: —

First Class.

Plot 4. — Nitrate of soda, cotton-seed hull ashes and castor pomace.

Plot 3. — Nitrate of soda, cotton-seed hull ashes and cotton-seed meal.

Plot 9. — Nitrate of potash, cotton-seed hull ashes and cotton-seed meal.

Plot 10. — Nitrate of potash, carbonate of potash-magnesia and phosphatic slag.

Second Class.

Plot 6. — Nitrate of soda, high-grade sulphate of potash, cotton-seed meal and dissolved bone-black.

Plot 8. — Nitrate of soda, high-grade sulphate of potash, linseed meal and dissolved bone-black.

Plot 7. — Nitrate of soda, high-grade sulphate of potash, castor pomace and dissolved bone-black.

Third Class.

Plot 1. — Nitrate of potash, potash-magnesia sulphate, cotton-seed meal and dissolved bone-black.

Plot 2. — Nitrate of potash, potash-magnesia sulphate, castor pomace and dissolved bone-black.

The observations with barn-yard manure have not been considered in the above classification; they are very encouraging, but not sufficient in number to permit detailed discussion in this connection; besides, the amount of barn-yard manure used in our experiment, ten tons per acre, contained nearly two hundred pounds of potassium oxide and

from thirty to forty pounds of available phosphoric acid less than our formula of commercial fertilizing ingredients called for.

An early application of barn-yard manure, properly supplemented with a suitable potash compound and available phosphoric acid, has produced excellent results in other localities.

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